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SOME DATA ON THE EFFECT OF TEMPERATURE AND MOISTURE ON THE RATE OF INSECT METABOLISM

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Introduction

As more pressing duties would permit, the writer, while connected with the Agricultural College and Experiment Station of Kansas, devoted his time to the study of the relation existing between the temperature and moisture factors of the environment and the insect life subjected to them. The work covered only a small part of the field that had been laid out and covered that in a very incomplete manner. Nevertheless a considerable amount of data partly confirmatory of previous work and partly bringing new facts to light has been accumulated, and, inasmuch as the progress then made may otherwise be lost, the writer has decided to put the matter in shape for publication.

Temperature

Recently temperature, as directly affecting the insect, has both in this country and in Europe received considerable attention. Bachmetjew[1] in Europe has summarized the relationship of temperature to insect metabolism in the form of a general curve which was brought to the attention of the Association of Economic Entomologists at the Boston meeting in the year 1910. In a series of stimulating papers, Sanderson[2] in this country has pointed out that the rate of insect

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[1] Bachmetjew, P., Experimentelle Entomologishe Studien, Erster Band, Leipzig 1901 and Zweiter Band, Sophia 1907.

[2] Sanderson, E. D., particularly "The Relation of Temperature to the Growth of Insects." Jour. of Econ. Ent., vol. III, pp. 113-139.

metabolism is not only variable at different temperatures, but varia for different developmental stages at the same temperature and, wh is still more striking, variable for the same developmental stages un the same temperature at different times in the year. He points that consequently the curve, illustrating the temperature relations of each developmental stage for each period of the year when it occ must be determined before the measurement of the temperature eff can be made exact.

The work thus far has served to emphasize the absolute neces for the systematic accumulation of data relative to the tempera effect, and it is for the purpose of presenting some of this ty of matter that the temperature portion of this paper has be written.

The material used in this study was the apterus female of the sou ern grain louse (*Toxoptera graminum* Rodani), its chief parasitic ene (*Lysiphlebus tritici* Ashm.) and the chinch bug (*Blissus leucopterus* Say with and without chinch-bug fungous (*Sporotrichum globuliferum* Spe infection.

The materials for the study of the southern grain louse and its para site were taken at the beginning of each experiment from outd conditions when the season of the year permitted, and at other ti from greenhouse rearings. The chinch bug material was taken dire from the field at the beginning of each experiment.

In all cases, except two, the tests were made in constant temperat and moisture incubators of the type described to the Entomologi Society of America at Boston in 1910. The two exceptions w breedings made in the greenhouse for the purpose of finding what d ference, if any, could be attributed to breeding under the incuba conditions. The organisms under experiment were in all cases su plied with an abundance of attractive food, consisting of young wh plants. Each test with the southern grain louse involved carry from six to forty-one individuals throughout their life cycles. E test with its parasite involved, taking the average of the respons from two to ten pairs and their progeny. Each test with the ch bug involved the response of about twenty individuals.

In summarizing the meaning of these temperature data it ma said that the response of insect protoplasm, as exhibited in variat of the rate of metabolism, appears to depend upon: (1) where in particular insect's temperature range the temperature changes oc (2) the type of metabolism characteristic of the insect, when response is taken; (3) the presence of any abnormal factor such parasitism.

TABLE SHOWING THE EFFECT OF TEMPERATURE CHANGES ON THE RATE OF METABOLISM IN CERTAIN INSECT SPECIES

Factors Considered	Const. Rel. Humidity	Constant Temperature					Species of Insects
		50° F.	60° F.	70° F.	80° F.	90° F.	
No. of days from birth to maturity	75%	32	15	9	6	8	Toxoptera graminum
No. of days from birth to death	75%	59	30	20	12	10	Toxoptera graminum
Daily rate of reproduction	75%	.9		2.6	3.1	1	Toxoptera graminum
No. of days to first evidence of parasitism	75-100%	18		5	4	4	Lysiphlebus tritici
No. of days to max. emergence	75-100%	43		10	10		Lysiphlebus tritici
No. of days to max. death	100%	27		6		6	Blissus leucopterus infected
No. of days to max. death	100%	46		11		6	Blissus leucopterus uninfected

In this connection, the relation between the effect of constant temperature and of average means should be pointed out. The accompanying table shows that the constant temperature is much the more

No. of Individual Insects	Moisture	Temperature	Days from Birth to Maturity	Days from Birth to Death	Daily Rate Reproduction
[illegible] T. geaminum		Av. 60° F.	19	76	1.4
4 "	Av. 75.3%	Av. 80.5° F.	8	30	1.5
2 "	Const. 75%	Const. 80° F.	6	12	3.1

powerful, considerably shortening the growth stage and length of life and increasing the daily rate of reproduction, and when taken with the preceding table also shows that, except in reproductive activity, the rate of increase for the twenty degrees of change from 60°F. to 80°F. is practically the same under the average mean as under the constant conditions.

MOISTURE

The effect of moisture on the rate of insect metabolism has received much less attention than has the effect of temperature. Davenport,[1]

[1] Davenport, C. B., Experimental Morphology, vol. II, p. 360.

summarizing the effect of water on protoplasmic growth, says: "Water plays a part in growth second in importance to no other agent, so that in its absence growth cannot occur. As the quantity is increased growth is increased until an optimum is reached. The amount imbibed does not, however, depend directly upon the amount available, but rather upon the needs and habits of the species." In summarizing the effect of moisture on insect life we find Bachmetjew[2] saying in 1907 (1) that there is an optimum moisture for insect development; (2) that this optimum is not the same for different species; (3) that the moisture which may hasten the development of one species may retard the development of another.

To these conclusions the writer desires to add another—that the rate of metabolism in certain actively feeding insects with an abundant supply of succulent food is not affected by large differences in atmospheric moisture.

The material used in this study consisted of southern grain lice and of chinch bugs infected and uninfected with the chinch-bug fungus. In determining the effect of each percentage of atmospheric moisture on the southern grain louse, ten specimens were carried from birth to maturity. In working with the chinch bugs, a group of from twenty to eighty was used for the determining of each point. The specimens were taken from field or greenhouse (all chinch bugs came from the fields) as the season dictated at the beginning of each experiment. In all cases they were furnished with an abundance of succulent young wheat for food. As the accompanying table shows, the southern grain louse required six days to pass from birth to maturity under a constant temperature of 80° F. and relative humidities of 37 per cent, 50 per cent, 70 per cent, 80 per cent, and 100 per cent.

Factor Considered	Const. Temp.	Const. Rel. Humidity in %			
		37	50	70	80
No. of days from birth to maturity....	80° F.	6	6	6	6

Subjection of eighty infected bugs from date of infection to date of death under a constant temperature of 70° F. and percentages of atmospheric moisture of 40 per cent, 60 per cent, 80 per cent and 100 per cent, resulted in their death in nine or ten days. Subjection of uninfected bugs, under the same constant temperature to the same constant humidities, resulted in their death in eleven days.

[2] Bachmetjew, P., Experimentelle Entomologishe Studien, Zweiter Band, S. 1907, p. 689.

Factors Considered	Const. Temp.	Const. Rel. Humidity				Remarks
		40%	60%	80%	100%	
No. of days from infection to maximum death	70° F.	9	10	10	10	Infected flies
No. of days from beginning of experiment to death	70° F.	11	11	11	11	Uninfected flies

This lack of effect is not in any way opposed to conclusions already discussed and may be explained on the supposition that these creatures, having an abundance of watery sap available from the wheat plants, were able to take enough water with their food to keep their body fluids at the water optimum.

EFFECT OF TEMPERATURE UPON THE OVIPOSITION OF THE ALFALFA WEEVIL (PHYTONOMUS POSTICUS GYLLENHAL[1])

By T. H. Parks, *University of Idaho*

The following notes on the oviposition of the alfalfa weevil were made by the writer at Salt Lake City, Utah, during 1911 and 1912, while an assistant in the Bureau of Entomology and engaged in the investigation of this insect.

It has been observed, since the alfalfa weevil became a pest in Utah, that the extent of injury to the first crop of hay varied one year compared with another. The injury which resulted to the first crop during the spring and summer of 1912 was much less than the injury done during 1911. The weather conditions of the spring months, for the two years above given, were very different, and the spring temperature at the time the beetles were depositing eggs seems to be largely responsible for the different degree of injury done to the first crop. A week of warm dry weather during the beginning of oviposition results in a very large number of eggs being deposited in a short time. Consequently many more larvæ will be feeding at one time than is the case where the oviposition period extends over several months. As a result, the alfalfa is unable to withstand the attack of the worms, and the injury increases so rapidly that the growth of the plant is checked. With a view to finding out the direct effect of daily

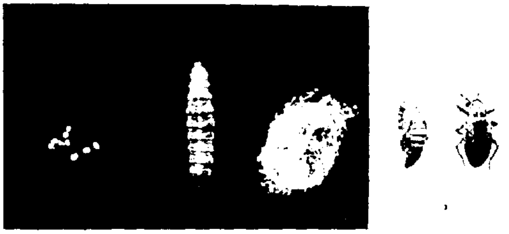
[1] Published by permission of the Chief of the Bureau of Entomology.

temperature changes upon the oviposition of the beetles, a series of experiments was begun to compare the variation in mean daily temperature throughout the oviposition period of the weevils, with the rate of oviposition of the beetles kept in confinement. An opportunity was also afforded to obtain accurate information upon the average number of eggs deposited by each female during the season.

The life history of the alfalfa weevil has been thoroughly worked out in Utah by Dr. E. G. Titus of the Utah Agricultural College and Experiment Station, and by agents of the United States Bureau of Entomology. A full account of this work can be found in Bulletin No. 110 of the Utah Agricultural College and Experiment Station, and No. 112 of the Bureau of Entomology, United States Department of Agriculture.

The beetles commence depositing eggs the first warm days of spring. The oval, lemon-yellow eggs are placed in clusters inside the alfalfa stems, through punctures in the stem made by the beak or snout of the beetle. They are placed in a row, being crowded both above and below the puncture, the last one often filling up the puncture made by the beetle. From two to thirty may be placed in one mass, though six to eighteen is the usual number. From one to four minutes elapse between the passage of each egg through the ovipositor and in each case the preceding egg is crowded up or down the alfalfa stem giving a symmetrical arrangement to the group (pl. 12, fig. 2). In early spring many eggs are deposited in punctures made in dead stems of the previous season's growth and which are lying on the ground where the beetles first crawl about. Later, a few are placed in green weeds and grass stems in alfalfa fields. By far the greater number are deposited in the green alfalfa stems, and these were used in the temperature experiments exclusively, the plants being grown under cover and care taken to have them free from infestation.

The beetles used in the experiments in 1912 were collected March 26 from alfalfa fields where they hibernated, and were placed out doors in small cylinder cages kept in the shade, and kept outside from the time the beetles were taken from hibernation until they ceased ovipositing and died. A male and a female were placed in each cage and fresh sprigs of alfalfa introduced frequently, and upon which they fed and in the stems of which they deposited their eggs. The eggs were counted daily, or every second day as the opportunity afforded and fresh alfalfa added. Sixteen pairs of beetles were used throughout the spring and summer, individuals being replaced when they died by other over-wintering beetles kept in reserve, so that the average daily oviposition record remained unbroken. The beetles began depositing eggs March 26 and continued until August 10, as shown by the



a b c d e

Fig. 1—Different stages of the alfalfa weevil
a–eggs; *b*–larva; *c*–cocoon; *d*–pupa; *e*–adult. All enlarged (original)

Fig. 2—Method of oviposition of the alfalfa weevil
a–beetle depositing eggs in stem of alfalfa; *b*–punctures in the stem made by the beetle in ovipositing; *c*–eggs in place in the cavity of the stem (original)

chart. The highest record for egg deposition was reached May 18, when an average of twenty-six eggs per female were deposited. This day also had the highest mean temperature of any day previous to June 6. The most of the eggs were deposited during May, and the rate of oviposition rapidly declined after the first of June, but was still influenced by changes in temperature, as shown by the record of June 24.

The temperature records were secured from the office of the United States Weather Bureau at Salt Lake City. The relation between the curves representing temperature variation and oviposition record is very noticeable, and the mean daily temperature seemingly affects the progress of oviposition until well into the summer.

The accompanying table shows the number of eggs deposited by each female first used in the oviposition experiments, or until she died and was replaced by another. The largest number of eggs deposited by any of these was 1,184, and the average for the series was 726 eggs per female. This is a fair estimate of the average number of eggs deposited by each female beetle in the fields during the season:

OVIPOSITION RECORD OF SIXTEEN BEETLES IN 1912 (*Phytonomus posticus* Gyll.)

No	Beginning of Deposition		End of Deposition		Date Beetle Died		No. of Eggs Deposited by Beetle
[illegible]	March	27	June	29	July	22	672
[illegible]	March	30	July	31	Sept.	4	779
[illegible]	March	29	May	29	June	6	520
[illegible]	April	6	June	13	June	14	675
[illegible]	April	1	June	27	June	29	933
[illegible]	April	3	July	19	Aug.	3	750
[illegible]	March	27	July	22	Oct.	9	666
[illegible]	April	6	June	19	June	27	401
[illegible]	April	3	July	8	July	13	972
[illegible]	April	6	April	29	May	8	128
[illegible]	April	6	June	1	June	21	532
[illegible]	March	30	July	4	Sept.	12	1005
[illegible]	March	30	July	8	Oct.	23	828
[illegible]	March	30	July	22	July	26	872
[illegible]	April	1	June	24	June	27	1184
[illegible]	April	1	July	8	Sept.	4	876
Average							726.4

In a series of experiments with eleven females collected from hibernation December 20, 1911, and allowed to deposit eggs in the warm laboratory room during the winter and spring, the average number of eggs deposited was 913. One beetle deposited 1,918 eggs.

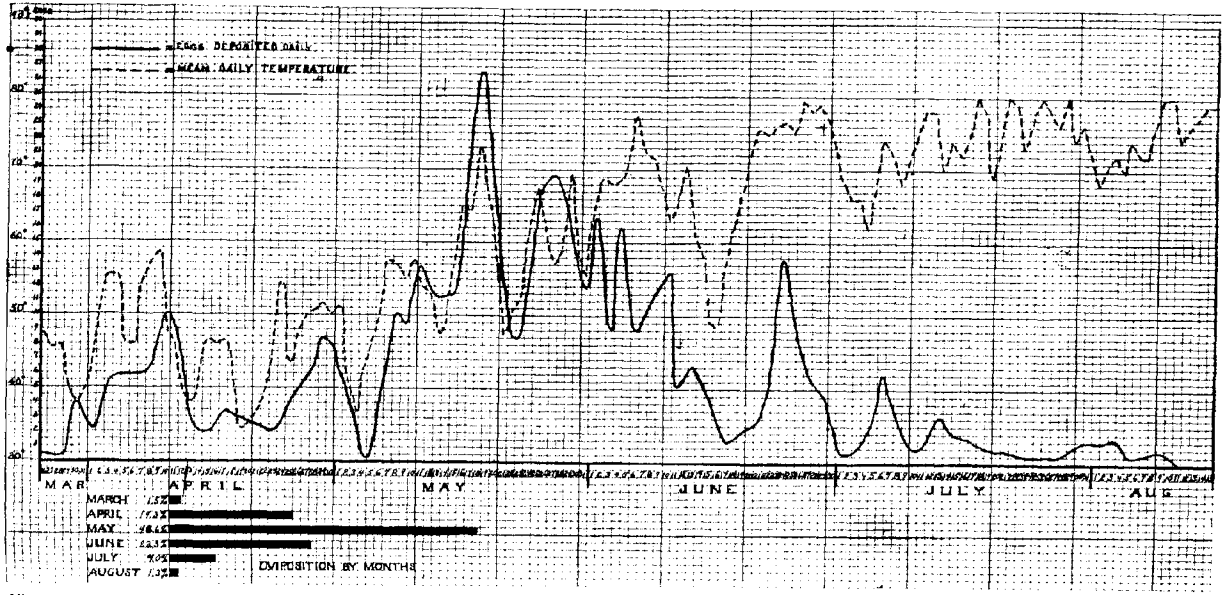


Fig. 22. Curves showing the distribution of oviposition of the alfalfa weevil (*Phytonomus posticus* Gyll) during the season of 1912, and the effect of change in temperature upon the rate of oviposition.

If we take the average number deposited in the 1912 experiments, and figure the rate of multiplication, there will be present at the end of the second generation 65,957 individuals, providing that one half of them are females and one half reach maturity. It is highly probable in the inter-mountain country that much less, than one half reach maturity and deposit eggs the following season, since many perish in the immature stages in fields of alfalfa after the removal of the first crop, and many which reach maturity are later carried by the wind into mountains and desert wastes where they must perish for want of suitable food. Among the individual beetles used in the 1912 experiments, oviposition did not progress uninterrupted throughout the season, but the "resting periods" were of short duration, and in most cases the egg deposition was fairly constant during the greater part of the season. Copulation occurred repeatedly during the entire period of oviposition, and all eggs saved for hatching showed a very small percentage of them to be infertile.

In the autumn of 1912 beetles which emerged from their cocoons June 10 to 13, deposited eggs in out-door cages the latter half of October. This, to all appearances, is the beginning of another generation, later interrupted by the approach of winter, but continued in the spring. Females taken from the fields, during November and December, deposited eggs in the laboratory continuously through the winter and spring. Eggs deposited in the autumn of 1911 were killed by the winter temperature, and, so far as known, all eggs deposited in the autumn either perish before hatching or the larvæ are killed by the winter, depending upon the weather conditions.

This represents, so far as known, the first accurate records of the average number of eggs deposited by the alfalfa weevil throughout the growing season, and the direct dependence of the same upon temperature. It would be natural to presume that a higher degree of prolificacy would prevail should the beetles become established in a region having a warmer climate and a longer growing season than characterizes the present area of infestation.

Acknowledgments are due to Mr. E. J. Vosler, now of the California State Insectary, for his assistance in taking records at times when the writer was away from the laboratory. Also to Mr. G. I. Reeves of the Bureau of Entomology for valuable suggestions in photography.

NOTES ON THE LIFE HISTORY OF PROSPALTELLA PERNICIOSI TOWER[1]

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Introduction

The following notes were taken during the early spring, fall and winter of 1913, and the spring of 1914.

This parasite, a description of which, both male and female, was published in the Ann. Ent. Soc. Am., vol. VI, No. I, pp. 125-126, is a true internal parasite, the larval forms living within the body tissues of its host, the female San José scale, *Aspidiotus perniciosus* Comst. except during the last part of the second larval stage as at this time the entire contents of the host are consumed by the larva, which, after passing its waste, pupates in the empty skin of the scale.

Both male and female parasites emerge from the empty skins of second-stage and early third-stage female scales, but by far the largest number emerge from second-stage scales.

The following description of the life cycle of the parasite, which has been worked out, is that of a parasite maturing in and emerging from a second stage scale. No doubt the development of those which emerge from third stage scales is the same.

The Egg

Developed eggs are readily seen within the abdomen of the female parasite when examined under the microscope at the time of emergence and many are even fully developed in the late pupal stage. They can also be examined as found in the bodies of first-stage and early second-stage scales.

The egg is ovate and has a distinct micropyle at the smaller end. The chorion is smooth and hyaline and the nucleus, located at the larger end, and the opaque granules, with which the egg is filled, show through.

The egg measures .085 mm. in length and .04 mm. in width.

The number of eggs deposited by an individual is not known. 1,364 developed eggs were obtained from twenty females selected as they emerged, giving an average of sixty-eight developed eggs apiece. Of the twenty females examined, the smallest and largest number of eggs found in a single specimen was forty-six and 102, respectively, and in most of these females there were still undeveloped eggs.

[1] Contribution from the Entomological Laboratory, Massachusetts Agricultural College.

Development of the Egg

The egg is usually found lying about medially in the scale and slightly nearer the pygidium end of the scale than the head end, although it may be found almost anywhere in the body. Here the egg swells in embryonic development to two to three times its size when laid and the young larva may be seen forming within it. The larva is practically fully developed before hatching and lies curled within the egg. On hatching it straightens itself out in the egg and the chorion, which has become very thin, is ruptured, allowing the larva to escape into the body of its host.

First Larval Stage

The larva, when hatched, is large compared with its host. Its mouth-parts, which were fully formed while in the egg, now become fully chitinized and the mandibles, which are the most prominent parts, are very sharp, strongly chitinized and decidedly hook-like.

The tracheal system, which lies close to the body surface and which was only partially filled with air when the larva was in the egg, now becomes filled and the two longitudinal main trunks, which lie on either side of the body meeting anteriorly and posteriorly, forming an oval, each show ten short stub-like branches.

Apparently there are thirteen body segments, the thirteenth or posterior segment lying partly within the basal portion of the tail. A distinct head region containing the mouth-parts is marked off. This region in the newly hatched larva is of the same diameter as the body, but subsequent growth enlarges the body, while the diameter of the head increases little if any. Thus the head region becomes more definitely marked off.

The tail is about one-fifth the length of the larva. It is seen in the embryonic larva lying close to the body, while in the hatched larva it is extended and is used for propulsion inside the host. A number of pointed folds or hyaline scales, which protrude slightly from the surface and point backward, are placed irregularly on the surface of the tail and these doubtless make the tail an even more efficient organ of propulsion.

Oxygen must be obtained through the skin or from the food eaten, as the larva lives submerged in a liquid medium having no connection with the tracheal system of its host or with the exterior, also its own tracheal system does not connect with the outside of its own body.

Feeding is carried on by means of a sucking pharynx aided by the mandibles. The ventral surface of the pharynx is a rigid chitinous

plate extending from the mouth backwards to the posterior limits of the head. The membraneous dorsal wall of the pharynx is raised from the ventral wall of the pharynx by muscles situated in the dorsal region of the head. These induce wave-like motions in the dorsal wall of the pharynx, which suck in and carry the food through the pharynx to the œsophagus. Here it is passed down into the stomach by the contracting action of the walls of the œsophagus.

The stomach is a blind sac in which the food is, during the early life of this stage, churned or rolled about by the movements of the larva. Later the stomach muscles become developed and constrictions, which run in waves from one end to the other, roll and turn the food content over and over, thus aiding digestion.

The posterior portion of the alimentary tract or proctodæum is scarcely developed and there is no external opening, as waste is not passed during this stage.

The larva at first feeds on the blood and smaller fat globules and avoids the vital parts as the growth of the second stage scale is not arrested until maturity has been reached. At this time usually the first larval stage of the parasite becomes full grown and apparently attacks, during its last days of growth, the vital parts of the scale, thus interfering with its normal functions and preventing the second molt of the scale from taking place. The scale, which previous to this time has been normal in its development, now becomes swollen and distended and at this time begins to turn from its normal lemon yellow to a light orange. The first molt of the parasite usually takes place at approximately the same time that the scale takes on the orange color.

The molting of this form terminates the first larval stage.

Second Larval Stage

This larval form is tail-less and its mandibles are not at first well developed, but soon grow to full size and become chitinized. The head region is indistinct and the body segments are practically indistinguishable.

The tracheal system lies deep within the body and at first contains little or no air, but soon becomes filled and develops rapidly. The first, second and fourth to ninth inclusive short branches of each longitudinal main trunk grow rapidly and terminally at the surface of the body develop spiracles, while the third and tenth branches remain short and do not develop spiracles. The two main longitudinal trunks are joined posteriorly and anteriorly as in the first larval stage and from these and the bases of the twenty branches are given off numerous branches which ramify to all parts of the body.

Respiration during the early life of this form is carried on in the same way as that of the first larval stage, but later as the fluid contents of the scale is consumed and an air space forms in the scale, some of the spiracles which have developed no doubt open and function. Without doubt by the time all the fluid content of the scale is consumed all the spiracles are fully developed and function.

The stomach is, as in the previous stage, a blind sac well filled with food. Its contents is even more thoroughly churned by more powerful contractions of the stomach walls. These contractions may start at either end running the length of the stomach, or starting at both ends run to the middle, or again starting in the middle run to both ends. The contents are at first the same yellow color as the scale, due to the fat globules swallowed, but later they become at first, due to digestion, a light orange, changing to dark orange and previous to being excreted a deep red to black color.

Feeding is carried on in the same manner as has been described for the first stage larva except that in the last part of this stage the mandibles, which are blunter and less curved than in the first stage, are used in destroying the internal organs and in scraping clean the inside of the skin of the scale.

The proctodæum is partially developed in the early part of this stage, but does not become fully developed or open until after the larva has consumed the entire contents of the scale and has entered a short quiescent period during which the contents of the stomach completes its digestive processes and is prepared to be excreted.

Following this period the waste, which has been accumulating in the stomach during the life of the two larval forms, is passed and is usually deposited along the lateral margins of the skin of the scale or at the ends. The chitinous portions of the proctodæum are passed out with the last of the waste and no doubt the chitinous portions of the fore-gut and tracheæ are also gotten rid of at this time.

The larva, following the passing of its waste, is usually found lying on its back with its head at the head end of the swollen skin which has dried and become a hardened case in which the parasite now pupates.

Pupation and the Pupa

Rapidly following the passing of the waste the larva usually begins to show differentiation into the three principal regions: namely, the head, thorax and abdomen. Following this condition, which externally marks the beginning of the pupal stage, pigmentation begins in the antennæ and its segments commence to form.

This coloration is quickly followed by that of the eyes, the dusky band of the fore-wings and a small portion of the ventral abdominal

plates. These last do not appear in any regular order. These area continue to darken for the next few days and the surface of the pupa becomes wrinkled, indicating the formation of the legs, mouth-parts and sclerites. Following this the abdomen and other pigmented or darkened portions of the body rapidly darken and the pupa becomes nearly black.

Previous to emergence the antennæ, legs and mouth-parts become free and the last larval skin is kicked off and the now active insect soon starts cutting and gnawing its way out. There is considerable variability in the length of time it takes for the adult to emerge. Some very active ones emerge in about three hours while others take a day or more. In emerging, a hole is made through which the head is thrust and the insect then pulls and pushes itself out, working its body from side to side and forward and backward, all the time lifting and pushing with its legs.

After emerging the parasite walks a few steps and then cleans itself and straightens out its wings. The insect spends some time in this way and then starts crawling about and is ready for copulation.

Duration of the Life Cycle

The following data are based on rearings of parasites in the laboratory at room temperatures which averaged from 68° to 72°F.

In working out the length of the different stages of this life cycle it has been found that the variability in the length of the different stages indicates a very elastic life history, and one well suited for its life in the host. Hence, it is impossible to give more than average time lengths for the periods.

Examination of large numbers of scales, during the spring of 191 at Amherst, shows that in general the scales survive the winter in two forms: first, that of well-grown, first-stage scales, which when parasitized contain eggs of the parasite; and, second, well-grown second stage scales, which, when parasitized, contain well-grown first stage parasite larvæ.

It has been found by raising parasitized scales of the first stage that the parasites reached maturity in from thirty-six to thirty-nine days while the parasites in the second stage scales matured in from nineteen to twenty-three days.

It is seen that the duration of the life cycle of those parasites raised from eggs compares favorably with that of the scale, thirty-three to forty days, as given by Marlatt. This is further supported by the observations of Dr. H. T. Fernald and the author that the scale in Massachusetts occurs in more or less distinct broods, and the examin

tion of large numbers of parasitized scales indicates that the broods of the parasite coincide with those of the scale.

It has not been possible to work out the length of the egg and first larval stage, as while this work was in progress young scales were not available for experimentation; however, it was possible to work out the other stages, and these subtracted from the total leave an average of from fourteen to nineteen days for the egg and first larval stages combined. Again according to Marlatt the female scale molts for the second time on the average eighteen days from birth and observations made on non-parasitized and parasitized scales show that the majority of the first stage parasite larvæ molt at approximately the same time that the non-parasitized scales molt the second time.

The length of the second larval stage averages from six to eight days.

The waste passing period, which terminates the growth of the second larval stage and ends arbitrarily with the pigmentation of the antennæ, averages from one to two days.

The pupal stage averages from eleven to twelve days. Internal pupal development commences during the waste passing period.

Copulation

Sexual reproduction seems to be the rule as copulation has been observed to take place in hundreds of cases among insects that emerged both in the spring and fall. The percentage of males to females seems to be about equal, as of 463 insects selected at random as they emerged, 235 were males and 228 were females.

Copulation was found to take place as soon as the parasites had dried off after emergence and no doubt oviposition commences at once, for as stated earlier females previous to emergence contain developed eggs.

Males and females crawling about do not seem to locate each other from a distance by any apparent sense but more by accidentally coming very close or in actual contact. In such cases the male either pays no particular attention to the female or mounts her and is then either driven off or copulation takes place.

In copulation the male stands on the head and thorax of the female and rapidly pats and rubs her antennæ with his own and endeavors to draw the antennæ of the female to an erect position. The female may resist the male and drive him away; even in cases where copulation takes place the female usually resists at first, but occasionally not at all. When the antennæ of the female are raised to an erect position by the efforts of the male, assisted by the female, they are held behind and beneath those of the male and their tips are in con-

tact with the underside of the first and second basal segments of the flagellum of the male antennæ. The act of raising the antennæ seems to be that of assent, for copulation always follows this act. The male now shifts his position backward and grasping the abdomen and wings of the female with his fore and middle tarsi he leans backward and resting partially on his wing tips bends his abdomen between his hind legs which rest on the branch, and beneath the wing tips of the female and copulation takes place. Often a number of attempts are made before copulation finally takes place and this lasts from seven to sixteen seconds, the average length of time being from eight to eleven seconds.

During the act of copulation the female may stand quietly but usually walks, dragging the male with her.

After copulation takes place, the male again mounts the female and, drawing the antennæ of the female beneath and behind him as previously, the antennæ of the female having remained erect during copulation, usually stands quietly at first, occasionally moving his feet and gently patting her antennæ with his. Later he becomes restless and flits and fans his wings and finally leaves her, having stayed on her back from three to six minutes or more.

Polygamy and Polyandry

Emerging males and females were confined separately before copulation could take place and were then used to ascertain if the males would copulate more than once. A male and a female were confined together and copulation took place. The fertilized female was then removed and an unfertilized female substituted and the male readily copulated again, thus showing that they are polygamous.

The females that had been fertilized in the previous experiments were confined with males which had not copulated and these were under observation for two to three hours but copulation did not take place. Again often three or four males will attempt to copulate with one female and violent struggles take place among them, but in the cases observed only one male finally copulated with the female.

These last experiments indicate that polyandry is not, or is not the usual case.

Oviposition

The few cases of oviposition observed took place in young scales which had just formed a scale covering. In these cases the parasite crawled over the material on which she was placed until she found a young scale. This was examined by tapping it with the antennæ. She then turned back to the scale and thrust her ovipositor downward

and backward through the scale covering and into the scale until the tip of her abdomen almost touched the scale covering. While it was not possible to see the egg deposited in the scale it is evident that this takes place for, in the examination of first-stage scales, one finds the egg lying within the body.

The examination of mature first-stage scales, which are wintering over, shows eggs in all stages of development and even live larvæ may be found in the early stages of the second-stage scales as they are forming within the skin of the first-stage scales. From the large number of observations made upon first-stage wintering scales, which were brought into the laboratory to complete their development, it seems that the majority of the eggs hatch just as the second-stage scale is forming within the first-stage scale, although many hatch after the molt previous to the feeding period of the second-stage scale. Undeveloped and partially developed eggs have also been found in second stage scales after feeding and growth have begun. These scales developed from first stage scales in the laboratory and hence it is seen that these eggs were laid late in the life of the first-stage scale. The above data indicate that oviposition takes place all through the life of the first-stage scale, after it has settled down, and that normally the majority of the eggs are laid early in the life of the young scale and these complete their development in mature second-stage scales, while those eggs which are deposited late in the life of the first-stage scale hatch so late in the life of the second-stage scale that it would not be damaged enough by the parasite to prevent it from passing into the third stage. This, it is seen, would account for the fact that some of the parasites emerge from early third-stage scales. However, there is a possibility of the parasite ovipositing in second-stage scales, but this seems unlikely as even its early life is additionally protected by the first exuviium and in its later life it seems even less likely due to its large size as compared with first-stage scales normally oviposited in.

Large numbers of the scales are oviposited in twice and possibly even more times, but twice is the most that has been observed. As a rule when two eggs are found in one scale they are widely separated in development, showing that they were laid at different times and hence by different individuals. In other cases one often finds an undeveloped or a partially developed egg and a live feeding larva in the same scale. Only two cases of like development have been observed; one was in which the two eggs found were at the same stage of development, and the other was in which the two larvæ were of approximately the same age. However, from the large number of observations made, it should not necessarily be taken that the same adult laid the two eggs in the scale, but rather that the scale in these cases was oviposited

in by a second parasite the same day that the first oviposition took place. These facts together with the fact that only one parasite matures in and emerges from a single scale certainly shows that normally this parasite is uni-oviparous.

In the cases where the hatching of the larva from the second egg deposited occurs long enough after the hatching of the first egg, so that the first larva has had time enough to nearly mature or to pass into its second stage before the second larva hatches or is able to seriously interfere with its feeding, then the second larva attacks the first and enters its body usually posteriorly and does not greatly injure the first larva at first, as the second larva has been observed many times within the body of the first, feeding on the stored granular substances of the older larva while it was still feeding on the scale. In the case of wintering over forms, which will be discussed later, and in cases which have been observed in the laboratory, the second smaller larva does not greatly injure the first larva until after it has passed its waste and then with the rapid development of the second larva (during its second larval stage) the first larva is consumed and the second then passes its waste, pupates and emerges.

Probably, in cases where the eggs laid are not separated by enough time for the above to take place, the hatching larvæ destroy each other, or, on the other extreme, the egg resulting from the second oviposition is destroyed before it hatches by the larva hatching from the first egg.

Large numbers of male second-stage scales were also examined for the eggs and larvæ of the parasite, but none were found. This seems rather strange as it does not seem possible that the parasite distinguishes between male and female first-stage scales. Owing to the comparatively small number of male second-stage scales found, it not being possible to distinguish male first-stage scales from the female scales, there being certainly far fewer males than females as compared with the statement given by C. L. Marlatt (Bull. 62, n. s., Bureau Ent. U. S. Dept. of Agri., p. 43), that the male scales comprise 95 cent or more of those wintering over, the only suppositions then are that oviposition in male first-stage scales results in their death that in the material collected here at Amherst the males are actu much fewer and are not oviposited in.

Wintering over Stages

As stated previously the parasites pass the winter as undeve and partially developed eggs in the bodies of first- and second-s scales. The first larval stage also winters over in the second-s scales and also in the bodies of second-stage larval parasites, in

latter case usually lying centrally within its body. These second-stage larvæ are not arrested in their development by the second parasite within them in such cases, until after they have completed their growth and passed their waste. In the spring these first-stage parasites continue their growth consuming the older second-stage parasite larvæ and after passing their waste pupate and emerge.

Older forms of the parasite such as the second-stage larva, pupa and adults have not been observed to winter over.

It will be readily seen from the above that dormant or winter spraying would not only kill the scale but also the parasite.

Distribution

This parasite has been reported from Massachusetts, Pennsylvania and the District of Columbia, and the examination of material received from Drs. E. P. Felt, P. J. Parrott and W. E. Britton, entomologists in the states of New York and Connecticut, show the parasite to be present in those states.

Length of Life of the Adult

It was noted that the adult parasite died on the average in two days, when confined in test tubes plugged with cotton. Previous to this time adults had been observed drinking or feeding on sap and also on the bodies of crushed scales, so an experiment was tried in which the insects were supplied with water. The parasites drank readily and lived on an average four days under this treatment. Honey water was also tried, but the parasites did not live longer than those given water.

Fungous Enemies

It has been noted that the same fungi which attacks the scales as readily attacked the larval and pupal stages of the parasite, also that a number of parasites confined in test tubes died from the attacks of a species of *Empusa*.

Predaceous Enemies

The predaceous enemies of the scale, as *Microweisia (Pentilia) misella*, are incidentally destructive to the parasite in all its stages of development except the adult stage. However, as yet predaceous enemies of the scale in nowise control it and thus there is little danger of the parasite being extensively destroyed even in newly planted colonies.

Parasite Enemies

No cases of true parasitism have been observed, but a type of parasitism does occur which may be termed incidental or accidental, as such external parasites as those belonging to the genus *Aphelinus* which lie beneath the scale covering and suck out the entire contents of the second or third-stage San José scales; pupating between the scale covering and the empty skin of the scale and at the same time destroying the internal parasite as well.

Geotropism and Phototropism

The adult parasites show both positive geotropism and phototropism and these two reactions, together with the instinct of the parasite to search for scales, no doubt accounts for the fact that the scales on the smaller and outermost branches and twigs of infested material are well parasitized. This fact was also noted by H. E. Hodgkiss and P. J. Parrott (Jour. Econ. Ent., vol. VII, 227, April, 1914).

NOTES ON THE RICE WATER-WEEVIL (LISSORHOPTRUS SIMPLEX SAY)

By J. L. Webb, *Bureau of Entomology*

The amount of damage done yearly to the rice crop by the rice water-weevil is extremely hard to estimate. In most cases no rice is kill[ed] outright. On the other hand practically every rice field is infest[ed] to a greater or less degree. The effect of an attack is the pruning o[ff] of the roots near the base of the stalk. In severe attacks all the roo[ts] may be cut off, in others only a few. Where the pruning is not to[o] severe, the rice plant promptly throws out new roots, continue[s to] live, and will mature. Yet we do not know just how much has be[en] lost in weight or quality of yield. The difficulty is in finding a fi[eld] of rice entirely free from attack with which to compare infested fie[lds]. In extreme cases the rice plants are killed and the loss is then m[ore] easily estimated. In general, however, the loss from this sour[ce is] considerable, and well worth active efforts in the way of preven[tion] or elimination.

Seasonal History and Habits

According to the writer's observations the adult passes the wi[nter] in dead grass, especially grass that is matted down upon the gro[und]. In order to find the weevils in hibernation the grass must be li[fted] up and thoroughly shaken out, allowing them to fall to the gro[und]. Close examination of the débris is then necessary in order to dis[cover]

guish the weevils, as their general color is much the same as that of the dry grass. Great numbers of weevils pass the winter in this way. Mr. C. E. Hood, one of the writer's predecessors in the study of the biology of this insect, records the finding of large numbers of hibernating weevils in Spanish moss. The writer believes Mr. Hood's observations to be correct, for from his own experience he has come to the conclusion that dead grass is the more favored place of hibernation.

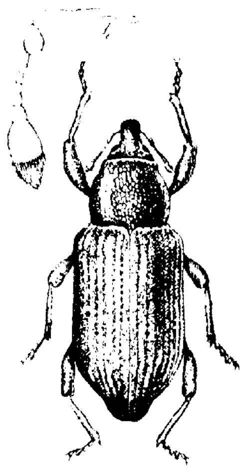


Fig. 23. *Lissorhoptrus simplex* adult enlarged, *b* antenna more enlarged (After Tucker)

Emergence from hibernation begins early and ends late in spring. The earliest date known to the writer upon which an adult has been observed to be active was March 25. The latest date upon which adults have been found in hibernation was June 26. This gives a period of three months for the emergence of the entire generation of hibernating individuals.

The adult weevils are usually not noticed in spring until the first flooding of the rice fields. Then almost immediately they are to be found swimming about in the water among the rice plants or resting upon the leaves above water. Sometimes they rest upon the leaves apparently for hours, but when touched promptly "play possum," fall to the water and swim away. They appear to be equally at home either in or out of water. However, it is impossible for them to breed in any but water plants.

Dissemination from hibernating quarters probably takes place mostly at night. The writer has never observed weevils in flight during the day. He has observed them quite frequently flying to lights at night.

The first injury to the rice plant occurs upon the leaves and is done by the adult weevils, probably both prior to, and succeeding oviposition. This injury takes the form of longitudinal feeding scars, the weevil eating out a longitudinal furrow in the leaf, just as broad as the spread of the mandibles. Only the thin epidermis is left where the feeding is done. Little real damage is done in this way, but the work is very characteristic of this species.

Copulation and egg laying apparently commence shortly after the adults reach the flooded fields of rice. When ready to deposit an egg the adult female crawls down the rice stem beneath the water and

Fig. 24—Egg of Rice Water Weevil in section of rice root. The egg has been exposed by removing the epidermis of the root. Enlarged (original)

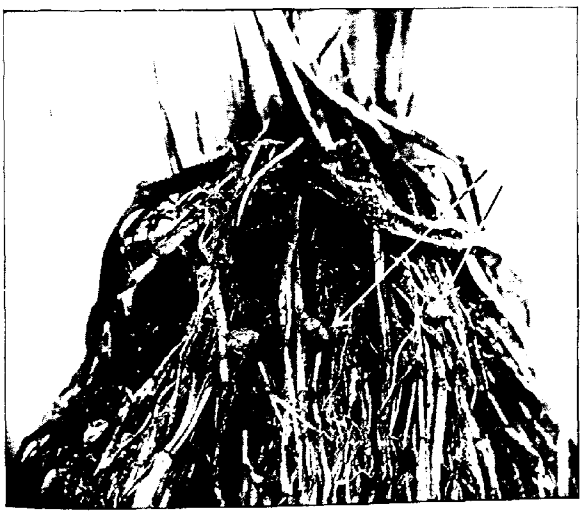
surface of dirt to one of the principal roots. Here she inserts the ovipositor, apparently by merely forcing the tip of this organ through the epidermis of the root. The egg (fig. 24) is then placed longitudinally just inside the epidermis. The egg is cylindrical, pearly white, and about one thirty-second of an inch in length. It is three or four times as long as broad and is barely visible to the naked eye. The writer, with the aid of a binocular microscope has found as many as three eggs laid end to end, apparently through the same hole in the epidermis. In other cases only one in a place was found. The microscope failed to reveal any evidence of the use of the mandibles in making the hole in the epidermis for the insertion of the ovipositor.

For the first few days of its existence the larva remains within the root in which it was hatched, feeding upon the inner root tissues and increasing in size. It advances along the root longitudinally, eating out a passageway as it goes. By the time it has exhausted the nutritive qualities of this first root, it is large enough to proceed farther and goes to another root undeterred by the surrounding mud. Whether it feeds little or much upon successive roots, practically all roots attacked are killed. Often several larvæ are found among the roots of a single plant (pl. 13) and work great destruction there. At this stage many of the larvæ are easily disclosed by pulling up infested rice plants and shaking the roots in water until washed clean of mud. Some larvæ always float on the surface of the water, while others sink to the bottom. When the roots of a rice plant are severely injured the leaves turn yellow, and according to Tucker[1] may even fall over upon the surface of the water.

When fullgrown, the larva is from one-fourth to one-half inch in length, very slender, and milk white. In preparation for the con... change, the larva gathers about itself an egg-shaped mass of dirt wh... it attaches to one of the healthy rice roots (pl. 13). The outside of ... pupal cell is uniformly even and oval in shape. It would be interes... to know just how the larva accomplishes this result, but in the na... of things observations along this line were impossible. Within ... pupal cell is a space from which water is excluded. Safe within ...

[1] Bureau of Entomology Circ. No. 152, p. 8 (footnote).

Larvae of *L. simplex* on Rice Roots



2 Pupal Cases of *L. simplex* in Natural Position on Rice Roots

retreat, as if to make itself doubly secure, the larva spins a thin silken sac or cover about itself. The writer has found as many as fifteen pupal cells attached to the roots of one rice plant.

The pupa shows somewhat the form of the adult, but is entirely white like the larva. The duration of the pupal stage is probably from one to two weeks. When fully mature the adult breaks through the wall of the pupal cell, crawls up the root to which the pupal cell was attached, and so escapes to the open air.

The length of time the insect spends in each of these four stages is not definitely known. However, the time from deposition of the egg to the young adult stage in the spring has been approximately determined. In a plot of rice which was first flooded on June 1, 1912, the writer found a young adult in a pupa case on July 8, 1912. The egg could not have been deposited before the rice was flooded, and, supposing it to have been deposited the first day of flooding (June 1) the time occupied in reaching the adult stage by July 8, was thirty-eight days, or five and one-half weeks. It is, of course, possible that even less time than this was actually occupied by the insect in passing through the different stages.

GENERATIONS

Various cage tests and field observations, conducted by the writer, have shown that, under favorable conditions, at least a partial second generation of rice water-weevils in a season is possible.

On July 29, 1912, a pan of growing rice, known to be infested with larvæ hatched from eggs deposited by over-wintered adults, was placed in a cage. By the side of this pan within the cage a pan of uninfested rice was placed, the object being to determine whether or not, when young adults emerged from the infested rice, they would deposit eggs on the uninfested rice, and so start another generation the same year. On August 31, 1912, the roots of two or three rice plants in the last mentioned pan were washed out, revealing one medium-sized larva. On September 23, 1912, the roots of several more plants in this pan were washed out and six larvæ were found. The pan of old rice from the other end of cage was then removed, and, no weevils being observed in the cage, a small quantity of dead grass (previously shaken out) was placed there to provide hibernating quarters for any adults that might later emerge from the remaining pan of rice. On April 6, 1913, the dead grass was taken out of cage and carefully shaken out over a table. Eight living rice water-weevils and the remains of one dead one were thus disclosed.

Another cage test, practically a duplication of that just described,

yielded on March 22, 1913, eighteen living *Lissorhoptrus* adults and thirteen dead ones in the dead grass at bottom of cage.

The following account of a cage test to determine the number of generations of the rice water-weevil is copied verbatim from the notes of the writer:

"Crowley, La., July 22, 1912: A few days ago I emptied Cage No. 3, and placed therein a pan of young growing rice. Today I released thirteen young adult *Lissorhoptrus* reared from pupæ, in this pan. Also placed in bottom of cage some dry grass suitable for hibernating quarters, and hung a bunch of Spanish moss in the opposite end of the cage.

July 26, 1912—Placed two more reared adults in pan.
July 27, 1912—Placed one more adult in pan. This one taken from pupa case in field.
July 31, 1912—Placed one more reared adult in pan.
August 1, 1912—Placed one more young adult in pan.
August 2, 1912— " " " " " " "
August 3, 1912— " " " " " " "
August 5, 1912— " " " " " " "
August 6, 1912— " " " " " " "
August 8, 1912— " " " " " " "
August 9, 1912— " " " " " " "

"September 18, 1912—Pulled up all rice in pan and washed ou roots in water. Only one small *Lissorhoptrus* larva found. Removed moss from cage and found two adult weevils in it. Removed dead grass from bottom of cage and found 114 weevils in it. Two weevils found in cage neither in moss nor grass."

From the foregoing it would appear that where a generation of weevils mature in early rice in the spring there is a possibility, and strong probability, of a second generation in late rice. For example near Rayne, La., on April 15, 1913, the writer found rice water-weev active in a field of recently flooded rice. By June 1, young adu were probably produced in this field. At that time of year there plenty of young rice recently flooded in which these young adults co deposit eggs for another generation.

The following field notes were made by the writer in the fall of 19

"Crowley, La., September 27, 1912: In a field of Japan rice, al a quarter of a mile east of the experiment station, I found today a living larvæ of *L. simplex* and three pupæ. These probably belon the second generation of the season. Larvæ and pupæ, however, scarce. A large number of rice plants were pulled up to find specimens just noted. The rice is headed out and apparently enough to harvest. Field has been drained but water still stand

low places. Most of the plants pulled up had roots severely pruned by *Lissorhoptrus*.

"Later in day found three or four *Lissorhoptrus* pupæ in a field of Japan rice about one and one-half miles south and a little west of experiment station. Field had been drained for cutting.

"Crowley, La., October 5, 1912: In same field (about one-fourth mile east of experiment station) in which I found larvæ and pupæ of *L. simplex* on September 27, I today washed out three living larvæ and one pupa of this species from Japan rice roots. Rice had been cut at this place, but the ground is still wet in places.

"Crowley, La., October 31, 1912: From rice roots pulled up yesterday in stubblefield, I today washed out a living *Lissorhoptrus* larva and one adult *Lissorhoptrus*."

The above observations show the latest fall records of the immature stages of this insect. Considering the period it takes for development from egg to adult—five or six weeks there would be ample time during the spring, summer and fall for more than two generations. However, it does not appear probable to the writer that there are more than two generations per year.

In the fall the adults of the last generation go into hibernation for the winter in dead grass, as already described. The earliest date in the fall, upon which adults have been found in hibernation in the field by the writer, is September 30.

Hosts Plants

During the summer of 1912, the writer conducted a series of cage tests to determine in what native grasses the rice water-weevil would breed. Different species of grass were transplanted to flat bottomed, galvanized pans. The roots were well covered with dirt and the pans then filled with water. They were kept filled with water above the dirt during the tests. Two pans were used in each cage. Sometimes only one kind of a grass was used in a pan, sometimes more than one. After the water was placed in the pans adult rice water-weevils were captured in rice fields and about one hundred weevils placed in each pan. After allowing ample time for the weevils to lay eggs in the roots of the different grasses, and for these eggs to produce larvæ, the roots of each kind of grass were washed out in water to determine whether or not rice water-weevil larvæ were present. The following species of grasses were found to be infested by the rice water-weevil: *Echinochloa zelayensis* H. B. K., *Paspalum dissectum* L., *Paspalum* ...*cianum* Flügge, *Syntherisma sanguinalis* (L) Dulac, *Capriola dacty-* ... (L) Ktze, *Axonopus compressus* (Sw) Beauv., *Panicum hians* Ell,

Panicum dichotomillorum Michx., *Jussiæa suffruticosa* L., *Eleocharis obtusa* Schult.

The following species were found to be not infested: *Paspalum dilatatum* Poir, *Commelina* sp., *Diodia virginiana* L., and *Eclipta alba* (L) Hassk.

The following species were found to be infested in the field: *Paspalum larrañagæ* Arech., *Paspalum plicatulum* Michx., and *Cyperus flavicornus* Michx.

Method of Control

Careful experiments have demonstrated that drainage is still the safest remedy for the rice water-weevil. The proper time to commence drainage of the fields is from two and one-half to three weeks after the first flooding, while the larvæ are still young. Drainage should continue for a period of two weeks. A shorter period of drainage will not kill the larvæ, and a longer period will injure the rice. Farmers should not wait until the rice begins to turn yellow before commencing to drain. The damage is practically all done by that time, and the rice needs water to enable it to throw out new roots and recover from the attack of the insect.

AGRILUS POLITUS SAY INFESTING ROSES

By Harry B. Weiss, *Assistant to State Entomologist, New Brunswick, N. J.*

During August, 1913, while inspecting nurseries in northern New Jersey in company with Mr. E. L. Dickerson of the New Jersey Department of Plant Pathology, our attention was called to the death of standard roses, the stems of which were swollen somewhat at different points. A number of infested stems were collected, some of which were sent to Dr. F. H. Chittenden. Under date of June 2 1914, Dr. Chittenden wrote that adults had emerged and had been identified by Mr. E. A. Schwarz as *Agrilus politus* Say, heretofore recorded as being bred only from willow. Unfortunately only one specimen emerged from my galls and Mr. C. A. Frost[1] was of the opinion

[1] Since writing the above, Mr. Frost informs me that Mr. Chas. Kerreman Belgium, to whom he sent my specimen, replied as follows: "I have examined your *Agrilus* very carefully; it seems to be a variety of the European *viridis* Linn. and resembles very much the var. *fagi* Ratz. but is smaller. The elytral sculpture and the bronze copper coloration are the same; only the head is a little more irregular, the front being less smooth. It presents all the specific characters of *viridis*, *fagi* is not on the whole as copper colored as viridis."

Undoubtedly it will be necessary to obtain a larger series before the doubt in this matter can be cleared up.

that it was a European species. Dr. Chittenden mentions however, that as far as he knows no one has ever studied the foreign species of this genus in comparison with the native ones. Inasmuch as a considerable amount of the injury occurred on standard roses which had been imported from Holland in the spring of 1913, it was at first thought to be an imported species. However, Mr. H. M. Quanyes, of the Phytopathological Institute of Holland, to whom I sent photographs of the gall and a description of the injury, replied that no such insect work occurs in Holland on roses.

NATURE OF INJURY: The work of the larva is characteristic of an Agrilus species and consists of a spiral band of channels in the sapwood, these channels being very close together for a distance of from three quarters of an inch to two and one half inches. After making these galleries, the larva goes up the stem in a zigzag fashion, sometimes just under the bark and other times irregularly through the pith and sapwood for a distance of from three to six inches where it constructs an overwintering larval chamber which serves for pupation in the spring, the adults emerging the early part of June. The swelling or gall on the stem occurs over the spiral band of channels and varies in size from being almost imperceptible to twice the diameter of the stem, depending, of course, on the size of the larva and its activity in making a spiral band.

On *Rosa rugosa*, these swellings were sometimes marked by longitudinal shallow splittings of the bark varying in length from one eighth of an inch to one inch. On stems not as woody as those of *rugosa*, the splittings were deeper and more open. As a rule, on *Rosa rugosa* only one gall was observed to a stem and it occurred anywhere from the ground up. In a few cases three or four were counted on a *rugosa* stem and five on a *carolina*.

The leaves of the infested roses first turn yellowish, finally withering completely and turning brown. The stem being weakened at the swelling breaks off easily. At one nursery in New Jersey, $200 worth of standard roses were destroyed because of this insect and at another required the services of two men for over two days to cut and burn infested stock.

VARIETIES INFESTED: Standard roses as a rule are grafted on *rugosa* stock and *Rosa rugosa* seem to be particularly subject to attack. In addition the insect was found infesting *Rosa carolina, Rosa blanda, Rosa multiflora Japonica, Rosa rubrafolia, Rosa nitida, Rosa setigera* and wild roses.

DISTRIBUTION: In New Jersey, infestations were found at Rutherford, Millburn, Springfield and Englewood. Mr. F. Windle, of West Chester, Pa., has noted injury to *Rosa rugosa* in that vicinity. Mr. H.

Hornig, of Philadelphia, has collected similar galls on wild roses at Bustleton, Pa., and Mr. E. L. Dickerson records them as occurring on wild roses at Nutley, N. J. Mr. Geo. G. Atwood of the New York Department of Agriculture writes that he has often seen abnormal swellings of rose stocks, particularly Manetti and multi-flora.

Considering the nature of the injury, it is evident that the cutting and burning of infested stems is the only method of control.

SOME COCCINELLID STATISTICS

By H. E. Ewing, *Oregon Agricultural College, Corvallis, Oregon*

In the western part of Oregon plant lice are very abundant and destructive. This is especially true in the Willamette Valley, where we find agriculture well advanced, the climate quite mild and vegetation luxurious. Among the various species found in the valley, few, if any, are more destructive than *Phorodon humuli* Schrank, the hop aphis; *Aphis brassicæ* Linn., the cabbage aphis; and *Aphis viburni* Scop., an aphid found on several garden and other plants.

We have in the valley also several well-known species of Coccinellidæ which usually do heroic work in checking the plant lice, but the writer has noticed the absence of a few species of these beneficial insects that are quite common in other sections of the country. Hence I decided to introduce some of these into this section of Oregon, and, as a preliminary step, have taken a few statistics on the relative numbers of the different species of coccinellids found feeding on the three species of aphids mentioned, and also feeding from the cell sap secreted by stipule glands of vetch plants. Data, which gives us some idea of the numbers of lady-birds present in any situation, and especially data which gives the ratios of the numbers of individuals of each species present and preying on any plant louse, are very serviceable in helping estimate the value of a species after it has once been introduced.

In order to get the population statistics we collected all adult beetles that were present in the following situations: feeding on *Phorodon humuli* Schrank, on hops; feeding on *Aphis viburni* Scop., on thistle; feeding on *Aphis viburni* Scop., on lamb's quarters; feeding on *Aphis brassicæ* Linn., on kale; and, lastly, feeding in vetch, chiefly from cell sap secreted by special glands on the stipules of the leaves.

The collections from hops were made August 19, 1913. We collected all of the individuals found above our knees and up to as high as we could reach. Later counts showed that 209 individuals were captured. These were distributed among the different species as follows: *Hipp*

damia spuria Leconte, 25; *Hippodamia convergens* Guér., 116; *Coccinella trifasciata* Cr., 12; *Coccinella transversoguttata* 1; *Cycloneda sanguinea* Linn., 53; *Adalia bipunctata* Linn., 2.

On August 19, 1913, collections were made of all the coccinellids found feeding on many thistles, upon *Aphis viburni* Scop. The total number of beetles found was 276. These were distributed as follows: *Hippodamia spuria* Leconte, 17; *Hippodamia convergens* Guér., 241; *Hippodamia parenthesis* Say, 2; *Coccinella 9-notata* Hbst., 7; *Coccinella trifasciata* Cr., 9.

On August 20, 1913, a large number of weeds, lamb's quarters, were examined and all adult lady-birds were collected. They were feeding on *Aphis viburni* Scop. In all 988 beetles were gathered. They belonged to six species, and in the following numbers: *Hippodamia spuria* Leconte, 30; *Hippodamia convergens* Guér., 913; *Hippodamia parenthesis* Say, 6; *Coccinella 9-notata* Hbst., 26; *Coccinella transversoguttata* Fald., 1; *Cycloneda sanguinea* Linn., 12.

In a kale patch feeding on *Aphis brassicæ* Linn., we collected 344 adult lady-birds. These represented all that were found on four rows of kale. The collections were made August 21, 1913. These different individuals were distributed among four species as follows: *Hippodamia spuria* Leconte, 28; *Hippodamia convergens* Guér., 314; *Hippodamia parenthesis* Say, 1; *Coccinella 9-notata* Hbst., 1.

TABLE SHOWING THE RELATIVE ABUNDANCE OF THE DIFFERENT SPECIES OF COCCINELLIDS FOR FIVE DIFFERENT SITUATIONS IN PERCENTAGE TERMS OF THE TOTAL POPULATION PRESENT

Situations	Relative Abundance Expressed in Percentages of Total Population Present							
	Hippodamia spuria	Hippodamia convergens	Hippodamia parenthesis	Coccinella 9-notata	Coccinella trifasciata	Coccinella transversoguttata	Cycloneda sanguinea	Adalia bipunctata
Feeding on *Phorodon humuli*, on hops . . .	11.9	55.5			5.9	0.5	25.3	1.0
Feeding on *Aphis viburni*, on thistles . .	6.2	87.3	0.7	2.5	3.3	-		
Feeding on *Aphis viburni*, on lamb's quarters	3.0	92.4	0.6	2.6	-	0.1	1.2	
Feeding on *Aphis brassicæ*, on kale . .	8.1	91.3	0.3	0.3		—		
Feeding on cell sap of vetch	8.69	87.05	--	2.69	1.26	--	0.31	---

The collections from the vetch fields were made June 4, 1913. We selected a strip of luxuriant vetch 240 feet long and six feet wide, and

collected all the adult beetles present. In our hunt we turned back and over the vetch plants in order to get the coccinellids from the lower leaves and the ground. This half-day hunt resulted in the capture of 633 lady-birds. The numbers of individuals of each species were as follows: *Hippodamia spuria* Leconte, 55; *Hippodamia convergens* Guér., 551; *Coccinella 9-notata* Hbst., 17; *Coccinella trifasciata* Cr., 8; *Cycloneda sanguinea* Linn., 2.

From these figures we get the following percentages of the total coccinellid populations for each species found in the different situations. They are given above in tabular form.

These percentages may be expressed graphically as I have done in Figs. 25 and 26. In Fig. 25 it is at once noted that *Hippodamia convergens* Guér. is by far the most common species, in fact the individuals of this species constitute a majority of the coccinellid population in each situation. Perhaps the next most striking feature noticed is the large number of individuals of *Cycloneda sanguinea* Linn., found feeding on the hop aphis. In the statistics for the other situations this species is quite rare, being absent entirely in the statistics for the cabbage aphis, on kale and from the counts for *Aphis viburni* Scop., on thistles. In four of the situations *Hippodamia spuria* Leconte is found to be second in numbers, as it doubtless is in importance. This is in accordance with a previous statement made by the writer (Journal of Economic Entomology, Vol. 6, p. 404), but without the authority of population statistics. With the exception of *Coccinella trifasciata* Cr., when found feeding on the hop aphis, no other species is found in such numbers as to equal or exceed 5 per cent of the total population for any environment. Hence these rare species are of little value from an economic standpoint on account of their small numbers.

In Fig. 26, we notice that similar conditions prevail in the vetch field. *Hippodamia convergens* Guér. predominates to the extent of constituting over 87 per cent of the total population. *Hippodamia spuria* Leconte comes second, while *Cycloneda sanguinea* Linn., common in the hop fields, constitutes only a little over .3 of 1 per cent of the total population.

In closing, I may add that the numbers of *Hippodamia spuria* Leconte, found in these situations as compared with those of *Hippodamia convergens* Guér., do not compare as favorably as they do the statistics obtained from hibernating masses. Here *Hippodamia spuria* Leconte will frequently be found to be present to the extent of about one-half the number of *Hippodamia convergens* Guér.

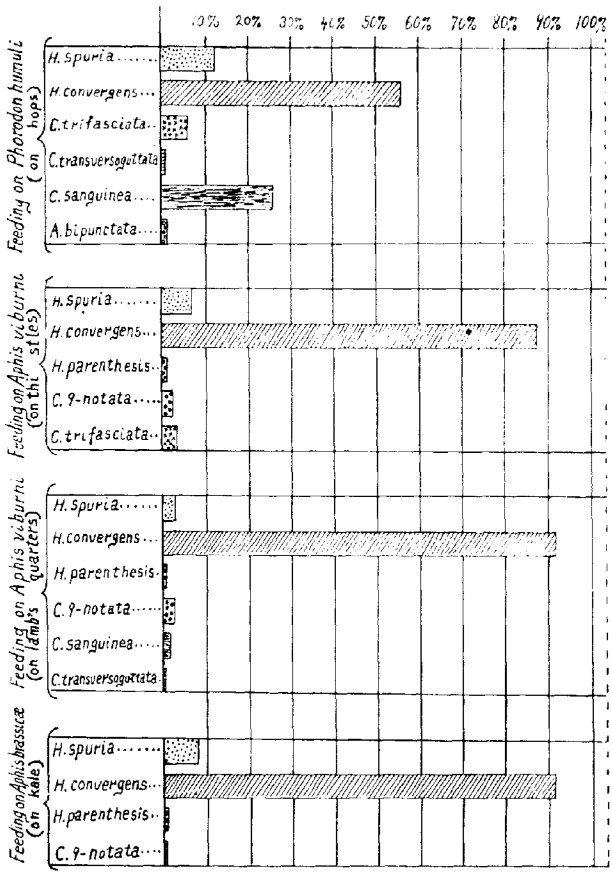


Fig. 25—Diagrams showing the relative numbers, expressed in percentage terms, of the total population of different species of Coccinellidae found in four situations

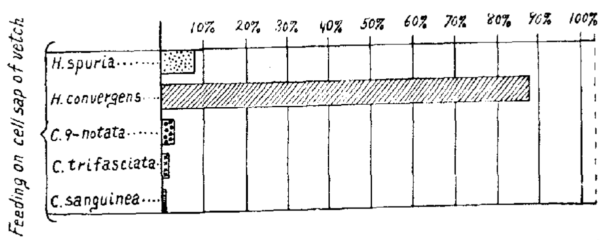


Fig. 26—Diagram showing the relative numbers, expressed in percentage terms, of the total population of different species of Coccinellidae found in each patch

A NEW PEST OF CANE IN FIJI (SPHENOPHORUS NEBULOSUS MACLEAY)

By J. F. Illingworth, Ph.D., *Professor of Entomology, College of Hawaii, Honolulu, T. H.*

This is a small beetle borer, similar in form to the ordinary cane borer (*Rhabdocnemis obscurus*). Though of smaller size it is exceedingly prolific; fortunately, for the present at least, it appears to do little damage to the sound cane. They deposit their eggs in any rupture in the stalk, hence they are very abundant in rat-eaten cane, or old stalks which are full of exit holes of the ordinary borer.

This beetle would prove a difficult pest to control if it ever became abundant enough so that it was compelled to attack sound cane. Its power of multiplication appears to greatly exceed that of the ordinary borer beetle. This fact was brought out during the breeding work of the Tachinid parasites, when the ordinary beetle borers were bred in large iron tanks, to obtain grubs for the flies. These tanks were filled with short cane stalks, and about two or three thousand of the adult beetles placed in each. Though we were careful to pick out all of the beetles of this smaller species, sometimes a few found their way in with the others. In such cases the smaller beetles produced so many eggs, in the souring cane, that their larvæ ate up most of the food from the larger species. In place of finding only one or two here and there in the stalk, as we do in the case of the larger grubs, these small larvæ were in dozens in each internode. They work along in parallel channels, side by side, and, unlike the large borers, never make rupture holes through the rind for air. Hence a parasitic fly, such as we have for the ordinary species, would have no chance to reach them.

It must be recognized that though the larger beetles were more than 100 to 1 of the smaller in the breeding tanks, referred to above, the conditions were not so favorable for their development. The larger species prefer fresh cane, though their grubs will continue to live in the stalks after they have become sour. A brief description of the several stages may help to recognize this new pest.

Larvæ. Numerous in parallel channels of injured or souring stalks; spindle-shaped, tapering gradually from about the middle towards the head and tail. Comparing them with the ordinary borer grub, the head is smaller in proportion; they lack the ventral enlargement of the fifth and sixth abdominal segments, and they usually remain straighter.

Pupæ. In cavities just within the rind of the stalk; without cocoon. This, and their small size will easily distinguish them from the ordinary borer.

ADULT. Small size, at least one-third less than the common species; reddish-brown when the beetles are newly emerged, becoming very dark-brown with age. The color is evenly distributed and lacks the darker spots that are found on *R. obscurus*. The feet lack the large pads, and the antennal knobs end rather obtusely.

The following description,[1] by William Macleay, from specimens collected in New Guinea, appears to agree for those in hand.

> *Sphenophorus nebulosus*. Reddish-brown, opaque; rostrum thickened and scaly towards the head and with a fine stria along the whole of its length; the club of the antennæ very short and truncate.
>
> The thorax is depressed and black on the median line. The elytra are strongly striate-punctate, the insterstices convex, the whole is indistinctly clouded with different shades of brown; the pygidium is rounded with four raised lines or costæ densely clothed with scales. The femora are unarmed. Length, 3 lines

Mr. Frederick Muir of the Hawaiian Sugar Planter's Experiment Station, collected specimens of this species in New Guinea, Amboina and Larat.

REMEDIES. The best possible method of control that suggests itself would be to expose all rotten discarded cane to the sun for several days. This could be done either by first burning the trash, which would greatly assist in the destruction, or by having the cutters throw all discarded stalks out on top of the trash.

THE PROBABLE BEST METHOD OF REARING CERTAIN SCARABÆID LARVÆ[2]

By A. A. GIRAULT

These rough figures concerning three or four types of cages used by us in North Queensland for rearing to maturity scarabæid larvæ of root-feeding habit taken from cane fields and elsewhere, probably indicates the best type or types of cages, but the results are complicated y a number of factors which, so far, we have had to ignore. One of hese factors is the relative hardiness or adaptability of the half dozen so species concerned (*Lepidiota, Anoplognathus, Xylotrupes Calodes* and so forth). Here all species are taken as equal in this respect, hich is very probably not so. Another complicating factor is the imber of insects per cage, varying greatly from a hundred or more three. In 1912, the average number per cage was about ten while

[1] Proc. Linn. Soc. N. S. Wales, 1887, 2d Ser., Vol. I., p. 192.

[2] Contribution No. 20, Bureau of Sugar Experiment Stations, Bundaberg, Queensland.

in 1913 it was about twenty-five. All of the cages were filled with sifted volcanic soil planted with corn; the larvæ were placed upon this soil and allowed to enter, in this manner selecting the most hardy, since the weaker ones were unable to enter and died upon the surface. The following types of cages were used: ordinary square wooden boxes (18 x 18 inches) kept in and out of doors; the same with wire gauze bottom and buried into the earth; ordinary red, earthenware flower pots kept indoors and wire gauze Tower breeding cages of various lengths buried in the earth for their entire depth. The tabulations are self explanatory, but maturities were counted if the pupa was successfully formed:

Year	Type of Cage	Total No. Larvæ	No. Maturing	Per Cent Maturing
1912	Wooden boxes, indoors	162	51	31.
	Flower pots, indoors	58	18	32.
1913	Wooden boxes, indoors	1070	47	4.[illegible]
	Wooden boxes, outdoors	1140	25	2.2
	Wooden boxes, miscellaneous	3137	162	5.17
	Flower pots, indoors	161	37	23
	Tower cages, buried	431	126	29.
	Wooden boxes, buried	405	117	28.8
		6564	583	[illegible]

It is quite probable that the 1912 results are high because of the fewer cages (only thirty-five), thus not obtaining a true average, but it may be equally probable that they were due to the better attention which each kind of cage received. Thus it would seem that the kind of cage mattered very little, providing they received good attention. The two hundred and fifty or more cages of 1913 were not as well looked after, individually, as were the thirty-five of 1912. Yet, for our purpose, it was much better to use a large number of cages with smaller returns from each, since in 1912 only sixty-nine maturities resulted, whereas in 1913 over five hundred adults were obtained.

A hundred per cent of maturities resulted in two cases in flower pots with three and seven larvæ; in an ordinary box with forty-fo[illegible] larvæ of *Xylotrupes*, 77 per cent matured; with twelve ceton[illegible] larvæ in a flower pot 88.3 per cent matured; of twenty larvæ [illegible] *Anoplognathus*, 45 per cent matured in the ordinary box; of *Lepidi*[illegible] larvæ, the next largest percentage obtained from one cage was 68 w[illegible] nineteen larvæ in a wooden box with gauze bottom, sunk into t[illegible] earth. In two other cages of the same type and with the same speci[illegible] 66 and 57 per cent of maturity were obtained with twenty-seven a[illegible] twenty-six units respectively. But in a buried Tower gauze cage of [illegible]

depth of forty-three inches, with fifty-five larvæ, 72 per cent reached maturity.

It must be understood that the larvæ reared in these cages were usually a half or more grown before collected, usually remaining in the cages from two to five months before they were ready to pupate.

The best type of cage for this purpose seems to be the Tower cage sunk into the earth, but wooden boxes with gauze bottoms are perhaps equally as good and are much less expensive. Flower pots would be the third choice. Good drainage seems the essential factor from the standpoint of the cage.

THE SERPENTINE LEAF-MINER ON COTTON

By E. A. McGregor, *Bureau of Entomology*

In the course of the investigations of cotton insects at Batesburg, S. C., made by the writer[1] during the seasons of 1911, 1912 and 1913, a number of interesting notes have been made on the serpentine leaf-miner of cotton. The insect is a Dipteron, *Agromyza scutellata* Fallen, belonging to the family Agromyzidæ. A general account, under the name *A. pusilla*, was recently published by Webster and Parks. The present paper deals more particularly with the species as an enemy of cotton and is, therefore, supplementary to the recent paper by Webster and Parks in the *Journal of Agricultural Research*.

This species has been identified by Mr. W. R. Walton of the Bureau of Entomology and A. L. Melander of Washington Agricultural Experiment Station as *A. scutellata* Fallen, and by Mr. J. R. Malloch as *A. pusilla* Meigen. Mr. Melander considers *pusilla* a synonym of *scutellata* after making a thorough study of his own and Mr. Malloch's material.

The species is by no means peculiar to cotton. In the United States it has been bred from quite a number of different hosts, representing fourteen families of spermatophytes as shown in the accompanying table:

[1] Both in the field observation and in the work incident to the breeding operations Mr. F. L. McDonough, of the Bureau of Entomology, was of substantial assistance to the writer.

TABLE I.—FAMILIES OF AMERICAN LEAF-MINER HOSTS

Family	No. of Hosts
Leguminosæ	9
Cruciferæ	9
Compositæ	4
Malvaceæ	3
Solanaceæ	3
Chenopodiaceæ	3
Curcurbitaceæ	1
Plantaginaceæ	1
Gramineæ	1
Fagaceæ	1
Hamamelidaceæ	1
Lobeliaceæ	1
Ranunculaceæ	1
Atriplíceæ	1

During 1913 the leaf-miner was bred from seventeen host species at Batesburg, which is the greatest variety recorded for any one locality. This suggests that the species is decidedly omnivorous, but the preceding table reveals an apparent preference for the legume and the crucifer families. This might tend to show that *A. scutellata* formerly had for its regular host a species from one of these two families. The seventeen Batesburg hosts are given in the table below:

TABLE II.—LIST OF LEAF-MINER HOSTS OBSERVED AT BATESBURG, S. C.

Cotton (*Gossypium herbaceum*)	Lobelia (*Lobelia cardinalis*)
Mustard (*Brassica campestris*)	Oak seedling (*Quercus* sp.)
Nasturtium (*Tropæolum minus*)	Jerusalem-oak (*Chenopodium botrys*)
Cowpea (*Vigna unguiculata*)	Mare's-tail (*Lechea villosa*)
Cocklebur (*Xanthium canadense*)	Roman wormwood (*Ambrosia artemisiifolia*)
Corn (*Zea maiz*)	Sweet-gum (*Liquidamber styraciflua*)
Dahlia (*Dahlia variabilis*)	Sunflower (*Helianthus annuus*)
English aster (Aster sp.)	Woodbine (*Parthenocissus quinquefolia*)
Kudzu vine	

The host plants of *A. scutellata* in Europe have been listed by Webster and Parks.[1]

Doctor Chittenden has suggested the name "clover leaf-miner" to distinguish the species, but since other plants are equally attacked it would seem preferable not to employ such a distinctive name. Webster and Parks, in a recent paper on this species on alfalfa,[2] propose the name "serpentine leaf-miner" which, to the present writer seems more appropriate.

[1] Jour. Agr. Res., vol. I, pp. 59–87, Oct. 10, 1913.

[2] Webster and Parks. The Serpentine Leaf-miner. Jour. Agr. Res., vol. no. 1, Oct. 10, 1913.

The life history on cotton has not been determined in all details, but in a general way it is fairly well established as will be shown by the following notes:

Egg

The actual deposition of the egg has not been observed on cotton. On several occasions numerous adults of both sexes were liberated under control upon cotton leaves. On these occasions many puncture marks were made on the upper side of the leaves, but no oviposition was effected. These incisions resemble precisely the ovipositional punctures which are always to be found at the point of origin of the tunnel, and it is very probable that they are made to incite the exudation of sap for feeding purposes. Thus, unlike oviposition in alfalfa,[1] the leaf-miner invariably inserts her eggs on the upper surface of the cotton leaf.

In the case of cotton, the leaf-miner adult makes a very characteristic egg-puncture in the leaf (see fig. 27, a, b, and c). A hole is first rasped through the dorsal epidermis and then a small chamber is excavated in the underlying palisade tissue. The formation of this chamber causes the overlying epidermis to become countersunk, thus giving somewhat the appearance of a crater or drum-head (best shown in fig. 27, c). It is, doubtless, into the innermost recess of this chamber that the egg is inserted, since it is always from this point that the tunnel begins. Measurements of a considerable series of punctures yielded these averages: longest axis, .138 mm.; shortest axis, .0942 mm.

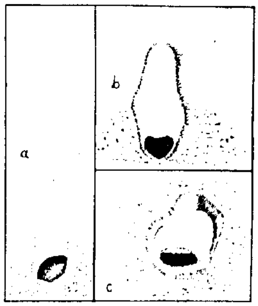


Fig. 27.—a, b and c three ovipositional punctures by *Agromyza scutellata*, × 90

Larva

Upon hatching, the larva feeds almost exclusively upon the palisade tissue near the upper surface, and consequently it is there (plate 14, fig. 1) that the mine is formed. If the infested leaf is held between the eye and the sun the entire feeding operations can be seen. Holding to the tunnel walls by means of two curved hook appendages (see plate 14, fig. 3, for the remains of these organs in the pupa) the leaf tissue is rasped by the ceaseless activity of a remarkable black, radula-

[1] Webster and Parks. The Serpentine Leaf-miner. Jour. Agr. Res., vol. I, no. 1, Oct. 10, 1913.

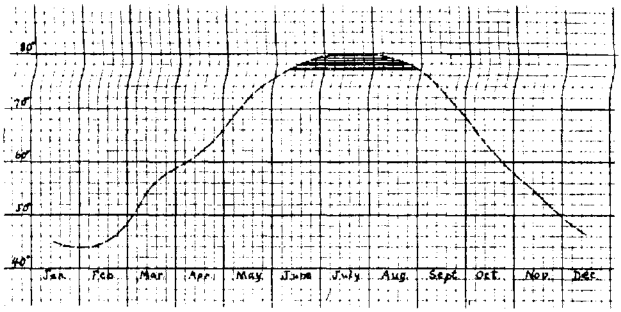


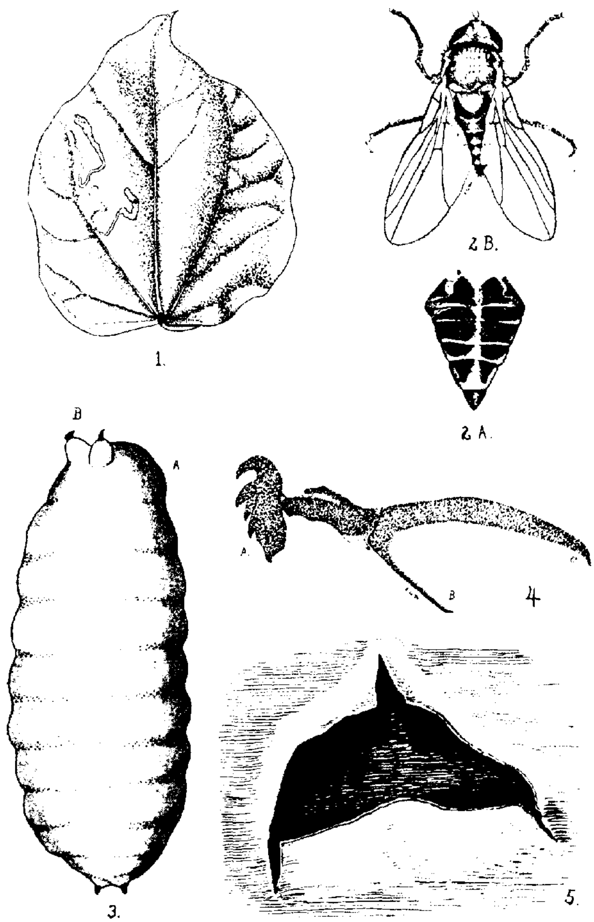
Fig. 28.—Diagramatic curve illustrating the seasonal gradations of temperature at Batesburg, S. C., and the approximate zone of mid-summer aestivation (shaded)

like organ (mandible) which may be extruded or retracted at pleasure. This structure is swung, like a mower's scythe, backward and forward with an arching sweep of the oral region of the larva. This rasping organ becomes vestigial in the pupa, but still remains visible as a black, anterio-median ventral prominence (see plate 14, fig. 3 a).

The cephalo-pharyngeal skeleton (of which the rasping organ is a part) is Y-shaped in outline and consists of the usual three closely articulated sclerites. The base of the Y (the middle on hypostomal sclerite) is directed forward and is extended terminally into a somewhat semicircular plate (plate 14, fig. 4 a). This plate, the distal sclerite, bears on its outer surface five or more sharp recurved teeth. The hook-bearing plate lies normally exposed outside the mouth. The arms of the organ are of unequal size. The upper arm (plate 14, fig. 4 c) is much longer and broader than the lower and is somewhat geniculate; the lower arm (plate 14, fig. 4 b) is short, straight and narrow. The entire device is densely chitinized, the rasping, hook-bearing sclerite being especially opaque. A thin hyaline border occurs on the inner face of the inferior lateral plate. No parastomal sclerites occur in this species, but the hypostomal segment bears a heavily chitinized ridge or process which in position and appearance is at least analogous, if not homologous, to a weakly fused parastomal.

The pivotal center of the device appears to lie at some point along the hypostomal segment. Muscle bands extend from the distal ends of the Y-arms to the cuticular integument, and it is obviously the alternate contraction of these muscles which imparts action to the external plate.

Leaves frequently harbor several individuals and as many as a dozen well-formed mines have been counted in a single cotton leaf.



Seedling cotton leaf with two mines of *Agromyza scutellata* (natural size): fig. 2B.-adult fly × 28: A. abdomen from above (Semi-diagramatic, to represent dorsal markings): fig. 3-pupa, dorso-lateral view, A and B appendages of same, × 55: fig. 4-detail of oral appendage of larva,—A armed mandible, B lower branch of cephalo-pharyngeal skeleton, C upper branch of same, × 200: fig. 5-exit incision in upper epidermis of leaf made by mature larva, × 75. (Author's illustrations).

The tortuous courses of the burrows occasionally sever the veins of the leaves, causing the death of more or less of the leaf tissue. It rarely happens, however, that one tunnel intersects another.

As the grub increases in size the caliber of the burrow expands (plate 14, fig. 1) until full development is attained at its cavernous end. Having reached maturity, the larva deserts the leaf dorsally through a somewhat crescent-shaped incision (plate 14, fig. 5) near the large end of the mine. Measurements of a series of these exit holes averaged 1.00 mm. for the longest axis and .42 mm. for the shortest axis. The average dimensions of a number of mature larvæ in natural position (unextended) were 2.00 mm. long by .55 mm. thick. Since the act of egg-laying has never been witnessed by the writer, it is impossible to record with exactness the duration of the larval stage at Batesburg. However, a series of twenty-three larvæ collected in very new mines averaged about four days to pupation. Probably about one or two days had been spent by these larvæ in developing the mines to the point reached at the time of collection. This would fix the duration of the larval stage in cotton at Batesburg at about five or six days, which is somewhat greater than that established by Webster and Parks for this stage.

Pupa

In the great majority of cases observed, the mature larva, upon escaping, sought the soil at the base of the stock for pupation. Usually the larva buries itself very shallowly—not much more than covering itself. In a few cases pupation has occurred on the under surface of the leaf from which the individual emerged. These are marked exceptions, however. In no case have we ever known a miner to pupate within the mine. The puparium at first is a pale straw-color but as normal development takes place the color deepens to a golden-tan. In the case of parasitism the puparium changes in color to a smoky-brown.

A rather large series of measured pupæ averaged 1.62 mm. long by .72 mm. wide. Data is at hand covering development from the immature larva to adult for sixty-seven individuals. We find that for Batesburg, S. C., the pupal period for May, June and July ranges between six and twelve days as extremes. The weighted average for all individual cases gives 8.67 days as the normal pupal period for summer temperatures.

The fly issues from the puparium through a rupture at one end. The only adults actually observed in the act of emergence liberated themselves in the morning between the hours of 8 and 9 o'clock. As previously stated, several attempts have been made to induce oviposition under control. Potted cotton seedlings were placed

within specially constructed cheesecloth shelters. After sufficient exposure to the tender foliage, very careful examinations revealed numerous punctures exactly similar to ovipositional apertures, but no eggs had been deposited.

Seasonal History

The leaf-miner becomes noticeable in cotton leaves when the seedlings are but a few days old. Young larvæ were seen the present season (1913) as early as May 10. This was a late season, however, and it is probable that May 1 usually marks the initial appearance in cotton of the miner. From that date the infestation increases rapidly until by the middle of June almost complete infestation occurs. In the season of 1912 only one computation of infestation was made, namely, upon July 12, at which time 84 per cent of the plants were infested.

During the present season (1913) more complete data concerning infestation has been secured. From May 26, when an infestation of 41.5 per cent obtained, the occurrence rapidly increased until on June 19 an infestation of 98.7 per cent was computed. In fact it can be said that during May and early June the leaf-miner is the most common pest of the cotton plant in the vicinity of Batesburg, S. C.

It is interesting to record that the activity of the leaf-miner becomes markedly reduced toward the end of June in South Carolina. This is probably brought about through the agency of two factors, namely, parasitism and æstivation. Our observations at Batesburg relative to æstivation are quite in agreement with those recorded by Webster and Parks. Subsequent to the 20th of June, the formation of new mines in cotton was reduced to a minimum. During July and August abortive, unfinished tunnels are often seen, but long search is usually necessary before finding well-developed mines during these months. Furthermore, it was noticed that such abortive mines, when removed to the laboratory for breeding, rarely gave issue to adult miners. During these midsummer months, however, it was usually an easy matter to find well-developed mines and larvæ in leaves of *Lobelia cardinalis* growing in shaded woods, or in leaves of the floral nasturtium (*Tropaeolum minus*) and of the English aster (*Aster* sp.) growing in shaded portions of gardens. Since the larvæ in these environments must be equally accessible to parasitic attack, there must be some other factor or factors at work in the open fields which enforces this reduced activity. Through analogy with other species where æstivation has been demonstrated as a factor of natural control, it is undoubtedly true that midsummer temperature brings about a cessation of activity. The precise point where activity ceases and æstivation

begins has not been determined with accuracy. However, from a coördination of the most rapid development of the species with the prevailing temperatures, it becomes evident that the most favorable conditions exist between 65° and 75° Fahrenheit, also that the reduction of the species begins with a mean temperature of 77° Fahrenheit. (See fig. 29 for seasonal curve and zone of æstivation.) It has not been definitely established exactly how many generations develop in the season at Batesburg, but it is quite certain that three broods occur on cotton prior to the beginning of æstivation. Following the period of æstivation, development on cotton is discouraged greatly by the toughening of the leaves.

From the general economic standpoint the serpentine leaf-miner as Webster and Parks have stated, is primarily an enemy of forage crops. The loss to these forage crops is occasioned through the fact that the useful part of the plant is the foliage. However, it is doubtful whether any crop plants—including the clovers—exceed the cotton plant in degree of infestation. As above recorded, we observed cotton fields wherein 98.7 per cent of the plants were infested.

Since the fruit, rather than the foliage, is the portion of the cotton plant which is utilized, it is difficult to estimate the injury which is occasioned through the ravages of the leaf-miner. It is probable that the greatest damage occurs while the plant is very young, since a few mines at that time might greatly weaken the struggling seedling. In fact, the cotyledons and the earliest foliar leaves are often shed prematurely through the work of the pest.

Parasitism

In the course of the observations on the leaf-miner at Batesburg, it became evident as the season advanced that several species of parasites were at work. Only one computation of the degree of parasitism was made, which was as follows: total number of leaf-miner pupæ, 74; pupæ parasitized, 21; perçentage of parasitism, 28.4. Parks found that at Salt Lake City, Utah, in September, 1911, 89.7 per cent of all Agromyza individuals were parasitized. It would seem, then, that natural enemies are much more of a factor of control in the alfalfa districts of the West than in cotton fields in the South.

Although no special attention was given to the rearing of leaf-miner parasites it develops that 7 Chalcidids, 2 Braconids, and 1 Dipteron—a total of 10 parasitic species—were bred during the investigations of 1913. As determined by Mr. J. C. Crawford, of the Bureau of Entomology, these are as follows: Chalcidids—*Zagrammosoma multilineata* Ashm., *Derostenus diastatæ* How., *Derostenus* 2 spp., *Pleurotropis* sp.; *Closterocerus* sp., *Chrysocharis* sp.; Braconids—*Opius* (2 spp.); Diptera—one species.

THE INTRODUCTION OF A TACHINID PARASITE OF THE SUGAR CANE WEEVIL BORER IN HAWAII

By Otto H. Swezey, *Honolulu, Hawaii*

The sugar cane weevil borer, *Rhabdocnemis (Sphenophorus) obscurus* (Boisd.), has long been a pest in Hawaiian cane fields. It probably became introduced along with shipments of "seed cane" from Australia early in the history of the sugar industry in Hawaii, and for several decades past has been generally distributed throughout the Islands, occurring in all of the plantations, and causing considerable loss of cane in many of them, often resulting in the destruction of half of the cane in fields especially favorably situated for them.

Various methods have been employed to check the ravages of the pest, with more or less beneficial results. After the remarkable success attending the introduction of the egg-parasites of the sugar cane leaf-hopper from Australia in 1904-05, it was decided to endeavor to find and introduce parasites for the borer pest also. Accordingly Mr. F. Muir was engaged by the Hawaiian Sugar Planters' Experiment Station to make a search for natural enemies of this weevil.

After considerable exploration of other sugar cane districts in search of the probable original home of the weevil cane borer and any parasites that it might have there, finally, at Amboina, in the East Indies, in 1908, Mr. Muir discovered a Tachinid fly[1] parasitizing a weevil infesting sago palms. The parasite was so effective that it was sometimes found to parasitize 90 per cent of the borers. As this borer was similar to the one in sugar cane in Hawaii (in fact, is to be considered only a local variation of the same species), it was thought that the introduction of this Tachinid to Hawaii should be attempted. In the summer of 1908, efforts were made to transport this Tachinid to Hawaii, by means of a relay breeding station at Hong Kong; but all attempts failed. The stages of the journey were too long for the transmission of the parasites in the pupal stage, and they would not survive cool storage.

Abandoning the transportation problem for the time being, Muir proceeded to British New Guinea for further investigations. Here he soon found the same Tachinid parasitizing a borer in sugar cane, which, on comparison, proved to be unmistakably identical with the borer in sugar cane in Hawaii. The Tachinid was found destroying a high percentage of the borers. Immediately plans were made for the transporation of the Tachinid to Hawaii. Mr. Muir found that he could breed the Tachinid on borers in cane in cages. Accordingly he

[1] *Ceromasia sphenophori* Villeneuve, Wiener Entomologische Zeitung, XXX, p. 81, 1911.

prepared cages to bring with him to Honolulu. Unfortunately he was taken down with typhoid fever on leaving Port Moresby, New Guinea, and on his arrival at Brisbane, Australia, was forced to abandon his voyage and go to a hospital. His parasite cages were sent on to Honolulu, but, lacking proper care en route, none of the parasites survived.

After several weeks in hospital, Muir recovered sufficiently to return to Honolulu, where after a short period of recuperation, he again undertook the introduction of this Tachinid from New Guinea. This attempt resulted successfully. It was accomplished by the use of relay breeding stations in the following manner. Mr. J. C. Kershaw, an entomologist whom Muir had met at Macao, China, was secured to assist in the undertaking. He and Muir met at Brisbane, Queensland, in January, 1910, to complete arrangements, by which it was planned that Kershaw prepare cages at Mossman, North Queensland, for breeding the Tachinids that Muir should collect and send him from New Guinea. Accordingly Muir proceeded to Port Moresby, New Guinea, and thence inland to the same place where he had previously found the Tachinid. There he collected puparia of the Tachinid and sent to Kershaw, the distance not being too great and the time involved short enough as to allow for their arrival at destination before the time for the emergence of the flies. When the latter emerged they were placed in the cages at Mossman already prepared by Kershaw with sugar canes containing numerous borer larvæ.

Muir continued sending puparia until Kershaw had the Tachinids satisfactorily breeding in his cages, when he joined him, and taking fresh puparia from the cages proceeded on to Fiji, where he established another breeding station. When this was successfully started and the Tachinids breeding satisfactorily, Kershaw abandoned the cages in Queensland, taking with him to Fiji more puparia of the Tachinid. On his arrival, Muir came on to Honolulu with a supply of Tachinid puparia, leaving Kershaw in charge of the breeding cages in Fiji, where he remained a few more weeks and then came on to Honolulu with additional supplies of the parasites.

Mr. Muir arrived in Honolulu with living parasites in August, 1910, and Kershaw arrived the following month. A part of the parasites they brought were liberated in cane fields where there was an abundance of borer larvæ in the cane in which they could breed, and part were retained for breeding in cages at the Experiment Station. The breeding in cages was soon going satisfactorily and was continued for two years, colonies of the parasites being liberated on the various sugar plantations as rapidly as they were available. They bred continuously, each generation requiring about six weeks, so that there were about eight generations per year.

After about six months the Tachinids were found established and increasing in those plantations where the first liberations were made; and in the course of about a year they were spread to all parts of these plantations, in some instances covering an area five miles or more across.

Now, after three years, they are established almost entirely throughout the sugar cane districts of the Islands. In those plantations where the borers previously caused the greatest loss of cane, little damage is now occasioned, and there has been a saving of many thousands of dollars to them. An indication of the beneficial reduction of the borers by this Tachinid may be gained by these comparative figures from one of the larger plantations where they have for a number of years practiced the collection of the adult borers from the cane fields. The past year 3,440 ounces of these beetles were brought in by the collectors; whereas, the previous year 27,010 ounces were collected, a reduction of over 87 per cent. Hardly an injured cane was to be found in some fields harvested this year, of the same plantation, where formerly a great deal of cane was lost by borers.

In another plantation formerly suffering severely from borer attack, there was a reduction of 44 per cent in the amount of damaged cane in the crop harvested the second year after the establishment of the Tachinid. In most places, examination shows a parasitization of from 50 to 80 per cent. Oftentimes it is difficult to find a borer that is not parasitized.

The method of attacking its host is quite unique in this Tachinid. The adult female deposits her eggs at openings in the rind of the cane where the borer larvæ feeding inside have come to the surface and made tiny holes. Frequently small maggots are deposited instead of eggs. The maggots search out the borer larvæ in the channels where they are feeding, penetrate the body and feed upon the juices and fat, eventually killing the host when it is about ready to pupate after having constructed its cocoon of wound-up cane fibers. From one to a dozen maggots may thrive in one borer larva, one, however, is sufficient to kill the latter. Having become full-grown, the maggots emerge from the empty skin of the host and form their puparia within its fibrous cocoon. Two weeks are spent in the pupal stage, and when the adult flies emerge they make their way out of the cocoon and from the cane through the hole which the borer larva, before constructing its cocoon, has instinctively made to allow for the escape of the adult borer when matured.

This is only a very brief account, but full details of the discovery, introduction, establishment and life history of this Tachinid will be given in a forthcoming Bulletin from the Hawaiian Sugar Planters' Experiment Station.

LIST OF ZOOPHAGOUS ITONIDIDAE

By E. P. FELT, *Albany, N. Y.*

The following records show that a considerable number of gall midges are predaceous and that this habit appears among widely separated groups. The list of 29 species is far from complete, since we have made no attempt to include therein, species which doubtless prey upon other gall midges, a habit typical of Lestodiplosis and probably other genera.

TABLE OF REARED SPECIES

Predator	Host
Coccidomyia pennsylvanica	Lecanium on beech
C. erii	Erium lichtensioides
Dentifibula cocci	Aspidiotus uvæ
Endaphis americana	Eriophyes on ash
Dicrodiplosis coccidarum	Orthezia and Dactylopius
D. californica	Pseudococcus
D. antennata	Phenacoccus
Mycodiplosis pulvinariæ	Pulvinaria
M. insularis	Tetranychus (red spider)
M. acarivora	Red spider on lemon
Aphidoletes marina	Aphis gossypii
A. cucumeris	Aphis gossypii
A. borealis	Aphid on tulip leaves
A. meridionalis	Siphonophora liriodendri
A. basalis	Aphids on Tanacetum (tansy)
Diadiplosis cocci	Saissetia nigra
Karschomyia cocci	Pseudococcus sacchari
Lobodiplosis coccidarum	Orthezia and Dactylopius
Arthrocnodax abdominalis	Red spider
A. occidentalis	Red spider
A. carolina	Red spider
A. apiphila	Beehive infested by mites
A. meridionalis	Eriophyes
Lestodiplosis grassator	Phylloxera galls
L. peruvina	Hemichionaspis minor
Lestodiplosis species	Aleyrodes
Itonida aphidivora	Aphis malifoliæ
Cecidomyia coccidarum	Orthezia and Dactylopius
Cecidomyia species	Cicada eggs

Summarizing the above we find that the scale insects or Coccidæ are preyed upon by the following nine genera: Coccidomyia, 2 species; Dentifibula, 1 species; Dicrodiplosis, 3 species; Mycodiplosis, 1 species; Diadiplosis, 1 species; Karschomyia, 1 species; Lobodiplosis, 1 species; Lestodiplosis, 2 species, and Cecidomyia, 1 species.

The plantlice or Aphididæ are attacked by Aphidoletes, 5 species; Lestodiplosis, 1 species, and Itonida, 1 species, the first genus evidently displaying a marked partiality for the Aphididæ.

Tetranychus or red spider is preyed upon by 4 species of Arthrocnodax and 1 of Mycodiplosis. It will be seen by referring to the above tabulation, that Arthrocnodax displays a marked partiality for the Acarina.

The plant mites or Eriophyidæ are preyed upon by 1 species of Endaphis and 1 of Arthrocnodax.

A species of gall midge, genus unknown, has been reared or was supposed to have been reared from the eggs of the periodical Cicada, *Tibicen septemdecim*.

It appears very probable from the above records, particularly in connection with the observations of Mr. E. A. MacGregor upon *Arthrocnodax carolina*, that the value of certain gall midges as natural enemies has been largely overlooked. There are probably a considerable number of other species, presumably mostly undescribed, which have similar habits.

ON THE ORIGINAL HABITAT OF STOMOXYS CALCITRANS

By F. Muir, *Taihoku, Japan*

In his interesting article on the geographical distribution of the stable fly,[1] Prof. C. T. Brues writes that "it is probably a native of the old world, most likely of central Europe," and, near the end, "It is probably native to the palæarctic region from whence it has followed man in his migrations to all parts of the world."

I am not able to follow Mr. Brues in these conclusions, and as they are of some importance in economic entomology, when endeavoring to discover parasites to control this pest, I would like to state my reasons for differing from an authority who has given this species a great deal of study.

In judging of the native habitat of a widely distributed insect like *S. calcitrans*, there are two points that I consider necessary to take into consideration: (1) the center of activity of the genus as indicated by the geographical distribution of the species of the genus; (2) the number and specialization of the natural enemies of the species under consideration, and its relative abundance in the different regions.

Turning to Brues' list of species of *Stomoxys*, and, if we leave out of consideration *calcitrans*, which is world wide, *nebulosa*, which is doubtful, and *pallida*, which is without given habitat, we have twenty-eight species, all of which belong to the Oriental and Ethiopian regions. Nine are native to India and Ceylon, and two a little to the east; fourteen to the African mainland and three to neighboring islands.

[1] Jour. Econ. Ent., Vol. 6, No. 6, 1913, pp. 459–477.

From this it appears that the center of activity of this genus is within the Indo-Ethiopian region, and, therefore, *calcitrans* is more likely to have arisen within this region than independently within the *palæarctic*.

Little is known of the parasites of this insect, especially in the Ethiopian region, but from my own observations in various parts of Africa I should say that it is less abundant there than in many extra-tropical places I have collected in. Seeing that the climatic conditions in Africa are more favorable than in temperate climates, the less abundance of this insect there may possibly be due to the presence of parasites.

Whether India or Africa was the birthplace of this species, it is difficult to judge, as there is no evidence to judge by, but my personal belief, unsupported by any direct evidence, is that the honor (or dishonor) should be given to Africa.

A NEW CECIDOMYIID FLY

By T. D. A. Cockerell, *Boulder, Colorado*

On July 15, 1913, I observed a large number of small gnats hovering over flowers of Japanese *Iris*, in the grounds of Mr. D. M. Andrews, about three miles east of Boulder, Col. These prove, on examination, to represent a new species of the interesting genus *Microcerata* Felt.

Microcerata iridis n. sp.

Male. Length nearly 2 mm.; reddish brown, with the legs cream-color; thorax redder than abdomen, the latter dilute sepia; wings clear hyaline with very pale veins; antennæ 9 jointed, the last three joints more slender than those before: palpi 4 jointed, the last joint very long. Very close to *M. spinosa* Felt, with the antennæ and palpi practically as in that species; but distinguished by the much larger size, pallid legs, subcosta joining costa before middle of wing; basal segment of clasp of genitalia swollen apically, terminal segment subbulbous basally and sharply bent apically, style as long as first segment of clasp. The following measurements are in microns: width of second antennal joint, 51; width of third, 37; width of ninth, 16; length of last palpal joint, 82; length of last segment of clasp, 75.

This is quite close to the fossil *Lithomyza* Scudder, but has the venation more modified from the supposedly primitive type.

a b

Fig. 29—Portion of venation;
a *Microcerata iridis*, b *Lithomyza condita* (latter after Scudder)

ADDITIONAL NOTES ON PORTO RICAN SUGAR-CANE INSECTS

By Thomas H. Jones, *Entomologist, Board of Commissioners of Agriculture of Porto Rico*

In the first three annual reports of the Experiment Station of the Sugar Producers' Association of Porto Rico, Mr. D. L. Van Dine, formerly Entomologist, published notes on the sugar-cane insects of the island. In the third annual report Mr. Van Dine gave a list of the insects affecting sugar cane in Porto Rico, including therein mention of their natural enemies, followed by a bibliography of Porto Rican sugar-cane insects. On pages 251 to 257 of the Journal of Economic Entomology, Vol. 6, No. 2, there also appeared in 1913 an article written by Mr. Van Dine, entitled, "The Insects Affecting Sugar Cane in Porto Rico." No annual report of the Station will be published this year and, as it is possible to present a few additional notes, the following supplementary information is here given for the benefit of economic workers, especially those interested in sugar-cane insects.

During the past year Mr. E. E. Green, the well known authority on *Coccidæ*, has advised us that, after examining specimens of sugar-cane mealy-bugs that were sent him from Rio Piedras, he finds that they "agree exactly with examples of *Pseudococcus calceolariæ* Mask," his determination being based "upon comparison with typical examples received from the late Mr. Maskell himself." Apparently this mealy-bug has not before been recorded as occurring in Porto Rico, all previous references to sugar-cane mealy-bugs being given under the name of *Pseudococcus sacchari* Ckll., which was first recorded from the island in a list of *Coccidæ* collected by Mr. August Busck during 1899. In connection with this list, which appeared in Bulletin No. 22, new series, of the United States Bureau of Entomology, it is stated that the determinations were made by Messrs. T. Pergande, T. D. A. Cockerell, and C. L. Marlatt. The material representing *Pseudococcus sacchari* was therefore probably examined by the author of the species.

On January 30, 1913, at Patillas, Mr. Van Dine found larvæ of a cecidomyiid in colonies of sugar-cane mealy-bugs, *Pseudococcus sacchari* (?). From these, adults were reared and specimens were forwarded to Dr. L. O. Howard, Chief of the United States Bureau of Entomology, who referred the specimens to Dr. E. P. Felt of the New York State Museum. Dr. Felt identified them as belonging to a new species which he has described as *Karschomyia cocci*.[1] In a letter,

[1] *Canadian Entomologist*, Vol. XLV, No. 9. Sept., 1913. pp. 304–305.

written subsequent to the publication of the description, Dr. Felt writes that "*Karschomyia cocci* belongs with a considerable series known to be predaceous, and there is very little question but what this insect is an enemy of the sugar-cane mealy-bug, . . . "

One new enemy of *Laphygma frugiperda* S. and A. has been observed. This is the common predaceous Reduviid bug, *Zelus rubidus*, which has been found attacking the *Laphygma* larvæ.

Mr. W. R. Walton of the United States Bureau of Entomology has described two new *Tachinidæ*, reared from Noctuid larvæ that feed upon the leaves of sugar cane. One of these, *Linnæmyia fulvicauda*, is parasitic upon *Remigia repanda* Fabr., the other, *Compsilura oppugnator*, upon *Cirphis latiuscula* H. S.[1]

The determination of an Hesperid, *Prenes ares* Felder, bred from larvæ found feeding on cane leaves, has been received from Dr. H. G. Dyar of the United States Bureau of Entomology. The larvæ of still another Hesperid have been observed upon cane foliage and Dr. Dyar states that this species "comes near *Thymelicus magdalis* H. S. from Cuba, but is obviously distinct." These Hesperids, together with the species already recorded, *Prenes nero* Fabr., are unimportant as pests of sugar cane in Porto Rico.

Two plant-lice are known to attack sugar cane in Porto Rico. One of these has previously been recorded from the island under the name of *Sipha graminis* Klt.[2]

More recently, material has been examined by Mr. J. T. Monell and Mr. John J. Davis of the United States Bureau of Entomology and they have determined the species as *Sipha flava* Forbes. The second species which has been referred to by Mr. Van Dine as "another species of aphis . . . at present undetermined,"[3] has been identified by Mr. Davis as *Aphis setariæ* Thos. The Chrysopid which feeds upon *Sipha flava* has been identified by Mr. Nathan Banks of the United States Bureau of Entomology as *Chrysopa collaris* Schm. *Aphis setariæ* is heavily parasitized by what Mr. A. B. Gahan of the United States Bureau of Entomology states is probably *Lysiphlebus testaceipes* Cress. The larvæ of a ladybird, *Scymnus roseicollis* Muls., have also been observed feeding upon it.

[1] Proceedings of the Entomological Society of Washington, Vol. XVI, No. 2, June, 1914. pp. 93–95.

[2] Hooker, C. W. Entomological Conferences in Porto Rico. Journ. Econ. Entom., Vol. 6, No. 1, pp. 148–150. p. 149.

Van Dine, D. L. The Insects Affecting Sugar Cane in Porto Rico. Journ. Econ. Entom., Vol. 6, No. 2, pp. 251–257.

Van Dine, D. L. Report of the Entomologist. Bul. 5 (3d Ann. Rpt.), Exp. Sta. of P. R. Sugar Producers' Assoc., August, 1913, pp. 25–46, pp. 32–33.

[3] Bul. 5 (3d Ann. Rpt.), Exp. Sta. of P. R. Sugar Producers' Assoc. p. 40.

Mr. A. A. Girault of Australia has reported that the Mymarid egg-parasite of *Delphax saccharivora* Westw. which occurs in Porto Rico is *Anagris armatus* (Ashmead).

At Rio Piedras during January, 1914, two species of thrips were taken from cane leaves on which characteristic thrips injury was noted. These were referred to Mr. J. D. Hood of the United States Bureau of Biological Survey, who has described one species as new to science, under the name *Haplothrips* (?) *tibialis*. The other species *Heliothrips femoratis* Reuter, represented by a single female, is, according to Mr. Hood, an abundant and destructive pest in the greenhouses of Finland, Sweden, Belgium, England, Italy, and the United States, its native home being open to conjecture.[1]

The mite which feeds upon the stalks of sugar cane, beneath the leaf-sheaths, Mr. Banks has identified as *Tarsonemus spinipes* Hirst. Although it was not described until 1912, this mite has been known to attack sugar cane in the West Indies for many years. Mr. W. Nowell, now Mycologist of the Imperial Department of Agriculture for the West Indies, well describes the injury it produces, as follows: "Causes small red blisters on the surface of the young internodes of sugar cane while still in the sheathing canes, which are also to some extent affected. Results in a reddish-brown corroded appearance of the surface of the cane, especially a streak above the eye."[2]

The mite which has been found working on the leaves of sugar cane Mr. Banks pronounces to be a species of *Tetranychus*, perhaps new.

ON THE VALUATION OF LIME-SULFUR AS AN INSECTICIDE[3]

By Herman V. Tartar, *Corvallis, Ore.*

At the present time, the object of the examinations made of samples of commercial lime-sulfur solution, in different chemical laboratories throughout the country, is to ascertain data regarding composition. In many cases, simply the total lime content, total sulfur content, and specific gravity are ascertained. Oftentimes, however, quantitive determinations are also made of the different forms of sulfur in combination. Entomologists and horticulturists, making field experiments, generally use a gravity test only.

[1] *Insecutor Inscitiæ Menstruus*, Vol. II, No. 3, 1914. pp. 38–41.

[2] *Bulletin of Entomological Research* (London), Vol. III, Pt. 3, Nov., 1912. p. 328.

[3] Contribution from the Chemical Laboratory of the Oregon Agricultural Experiment Station.

A large proportion of the lime-sulfur used is for insecticidal purposes. Consequently, examinations made in the valuation of the same should be quantitative determinations of those properties from which the spray derives its insecticidal value. Actual chemical composition is a secondary matter except in so far as it may be an indication or measurement of these properties. For this reason, the determination of specific gravity is perhaps of little value except in a very general way. Samples of lime-sulpur having the same specific gravity may not be alike in chemical composition nor in many other properties. For example, a sample having a low specific gravity may have a greater per cent of polysulfides than a sample having a somewhat higher specific gravity.

In this discussion of valuation, it is well first to consider the properties which give to lime-sulfur its insecticidal value. The most exhaustive investigation available is, perhaps, that of Shafer.[1] He showed that with scale insects, like San José scale, the calcium polysulfides present in the solution softens the so-called wax about the margin of the insect and, on drying, causes it to stick to the plant. In the cases tried, the insects stuck tightly enough to also cause the death of the young by sealing them under the scale covering of the mother. Shafer's work also strongly indicated that one of the principal, if not the principal, insecticidal effect of lime-sulfur solution, upon insects of the type mentioned, is its great power of absorbing oxygen, thus causing the treated insects to suffer because of an insufficient supply of this element. Other experiments made by Shafer showed that sulfur dioxide is not "formed in appreciable amounts from sulfur deposited by lime-sulfur except at temperatures much above those found under spraying conditions in the orchard." The liberation of this gas is, evidently, not in amounts large enough to make it of importance in any consideration of the insecticidal properties of the spray. The work done by the department of entomology of this station[2] indicates clearly that the principal insecticidal constituents are the calcium polysulfides. Experiments tried with calcium thiosulfate on San José scale [3] showed this material to have but little, if any insecticidal value. Wellington [4] arrived at similar conclusions. Shafer's [5] results also indicated that the thiosulfate has a limited insecticidal efficiency.

It has been known for long, too, that with certain insects, free sulfur has some killing power. It is stated that dry sulfur has been used in

[1] Tech. Bul. No. II, Mich. Agr. Exp. Sta.
[2] Unpublished results.
[3] Biennial Crop Pest and Horticultural Report, p. 112 (1913).
[4] Bull. 116, Mass. Agr. Exp. Sta.
[5] Loc. cit.

California perhaps a quarter of a century against almond red spider. The experimental work carried on by the experts of the California Agricultural Experiment Station[1] and the Bureau of Entomology, United States Department of Agriculture[2] shows that towards certain insects free sulfur has marked insecticidal properties.

There is also the possibility that hydrogen sulfide, a gas poisonous to insects, may be liberated from lime-sulfur when it combines with the carbon dioxide of the atmosphere or that given off in the breath of insects. So far as the writer knows, no means has been found to ascertain the extent to which this occurs. Experimental work carried out at this laboratory, however, indicates that if hydrogen sulfide is liberated under normal conditions it is in very small quantity, and, evidently, is not an important matter to consider here.

From the discussion preceding, it appears that, in general, the insecticidal properties of lime-sulphur are due principally to the following-named properties:

(1) Its power to take up large amounts of oxygen, (2) its ability to soften the newly secreted wax at the margin of scale insects, and (3) the amount of free sulfur formed in its decomposition. If this be true, then the question of the correct valuation resolves itself into the quantitative measurement of these factors.

The amount of oxygen consumed depends upon reactions as represented in the following equations:

$$CaS_5 + 3\,O = CaS_2O_3 + 3\,S$$
$$CaS_4 + 3\,O = CaS_2O_3 + 2\,S$$
$$CaS_2O_3 = CaSO_3 + S$$
$$CaSO_3 + O = CaSO_4$$

The combination of oxygen with the moist polysulfides is very rapid and quantities of the tetrasulfide or pentasulfide containing the same amount of calcium would absorb the same amount of oxygen and consequently produce the same amount of thiosulfate. This last named substance decomposes very slowly under ordinary conditions. For this reason, calcium sulfite is formed very gradually and the oxygen required to form the sulfate is absorbed slowly; too slowly, in the writer's opinion, to make it of insecticidal importance. Investigations made by the entomologist of this station indicate that calcium sulfite has practically no insecticidal effect upon San José scale.

The oxygen required to convert the polysulfides present in a given solution into thiosulfate can be easily estimated by the use of the methods of Harris.[3] The titration used in the determination of "mono-

[1] Bull. 154 and 234 Calif. Agr. Exp. Sta.

[2] Private correspondence.

[3] Tech. Bull. No. 6, Mich. Agr. Exp. Sta.

sulfide" (for explanation of this term see bulletin referred to) sulfur may be used in estimating the amount of oxygen which will combine with the polysulfide present to form thiosulfate. In this case, 1 cc. of tenth-normal iodine is equal to 0.0024 grams of oxygen. The writer suggests that this oxygen-consuming capacity might be expressed as the "oxygen number" (analogous to the iodine number of fats), this term meaning the amount of oxygen consumed expressed as per cent of the lime-sulfur solution, or, in other words, the number grams of oxygen absorbed by 100 grams of lime-sulfur.

Free sulfur is liberated from lime-sulfur by reactions represented by the following equations:

$$CaS_4+3\ O=CaS_2O_3+2\ S$$
$$CaS_5+3\ O=CaS_2O_3+3\ S$$
$$CaS_2O_3=CaSO_3+S$$

Since the oxidation of the polysulfide takes place rapidly there is a correspondingly rapid deposition of sulfur. The liberation of sulfur due to the decomposition of the thiosulfate is much less rapid. Considering everything, however, it appears that all of the sulfur liberated might be of equal insecticidal value; at least, there is no good evidence available to the contrary. The chemical estimation of the sulfur which will be deposited from a given amount of lime-sulfur solution can be made without difficulty. All of the sulfur present in the polysulfides in excess of that necessary to form the "monosulfide" of calcium combined in this form, would be deposited; also one half of the sulfur present as thiosulfate in the original solution. The chemical methods for making these determinations have already been worked out in a thorough manner[1] and it is unnecessary to go into a detailed discussion of them here. The author suggests that the total free sulfur which would be deposited might be expressed as the "available sulfur number," this term meaning sulfur deposited expressed as per cent of the original lime-sulfur solution.

The third insecticidal property mentioned above is not so easily estimated. In fact, it is not definitely known why the spray solution softens the wax on scale insects. It might be stated, however, that calcium thiosulfate is neutral in solution and gives no caustic effect on the hands, while solutions containing calcium polysulfide are very caustic. It is true that there is a small amount of calcium hydroxide in lime-sulfur solutions, due to hydrolysis of the polysulfide, but it is present in insufficient quantity to say that the caustic properties are

[1] Jour. Amer. Chem. Soc. 27, 244 (1905).
Jour. Ind. Eng. Chem. 2, 271 (1910).
Tech. Bull. No. 6, Mich. Agr. Exp. Sta.

due to the alkalinity of the solution. The writer's experience in handling the spray simply verifies the correctness of Shafer's statement that "the so-called caustic action of the wash on the hands seems rather due to its strong reducing power (power to absorb oxygen)[1] than to the alkalinity of the solution." It is very possible that this reducing power may also cause the softening of the so-called wax on the scale insects. If this be true, the "oxygen" number mentioned above would give its quantitative measurement. At any rate, the power of the spray to soften the so-called wax is evidently due to some property of the polysulfides and in the light of present knowledge no definite statement can be made regarding its exact nature nor its exact quantitative analytical measurement.

In conclusion, the writer wishes to state that the above discussion is merely a suggestion to chemists and entomologists. There may be other insecticidal properties of the spray than those mentioned and it is possible that the ordinary methods of valuation now in use are the best. If not, the discussion given here may prove to be of some value.

NOTES ON COCCIDÆ FOUND IN PERU

By E. W. Rust, *Assistant Government Entomologist, Lima*

Prior to the year 1909 very little entomological work had ever been done in Peru and, as a consequence, very little was known and almost nothing had been published relative to the insect life of this country. However, during the latter part of the year just mentioned, the Peruvian government established a bureau of entomology under the able guidance of Prof. C. H. T. Townsend. Among the many activities of the latter was the beginning of a collection of Coccidæ from as many hosts as possible and from all parts of the Republic, with complete notes relating to each lot of specimens.

When the writer arrived, during the latter part of 1911, this collection already numbered hundreds of lots of specimens, at that time all unidentified, many of which were of the same species but upon different hosts or from different localities. Since that time the collection has been greatly augmented both by Professor Townsend and by the writer whose pleasant task it has been to determine the species represented.

In many cases the coccids herein noted have never before been reported from South America and with the exception of only two or three species, this constitutes the first publication of their occurrence

[1] Words in parenthesis inserted by the author.

in Peru. It is with the idea of making known the new localities and new hosts of those coccids already determined, that this article is written.

Aspidiotus camelliæ Sign.

This coccid has been found more or less abundant in all parts of the Republic, so far visited, where its hosts exist but scarcely ever in sufficient numbers to cause it to be regarded as a serious pest. It is evidently kept well in check by microhymenopterous parasites which are not only numerically great but also include several different species.

Collected as follows in Peru: on *Salix humboldtiana*, Acobamba (elevation 9000+ feet); *Cordyline terminalis*, Lima; *Nerium oleander*, Lima; *Baccharis* sp., Huancayo. Also noted on many other plants throughout the Republic.

Aspidiotus cyanophylli Sign.

To date this scale has been collected only four times by the writer, but has, doubtless, been overlooked in other instances and will be collected in the future as this work progresses, as this climate seems very suitable to its multiplication.

On *Musa paradisiaca*, Hacienda San Jacinto (Department of Piura); *Carica papaya*, Lima, *Cinnamonum* sp., Lima; *Cocos* sp., Lima.

Aspidiotus cydoniæ Comst.

Collected as follows: on peach, Lima; rose, Hacienda Santa Clara (Department of Piura); *Morus alba*, Lima; *Eriobotrya japonica*, *Cinnamonum* sp., Lima; *Nerium oleander*, Samán (Department of Piura).

Aspidiotus hederæ Vall.

Collected as follows: on *Dracæna* sp., Lima; *Cordyline terminalis*, Lima; *Dianthus chinensis*, Lima; *Ligustrum japonicum*, Lima, and at Arequipa; *Magnolia grandiflora*, Lima; *Nerium oleander*, Lima; *Eriobotrya japonica*, Lima.

Aspidiotus juglans-regiæ Comst.

This scale is evidently an introduction, probably of the last few years, and has not yet become widespread in this country, although climatic conditions around Lima (near where the specimens were collected) seem favorable to its reproduction.

Recorded from Peru only in one instance as follows: Hacienda Ñaña (between Lima and Chosica) on *Juglans* sp.

Aulacaspis rosæ Bouché

This insect is a pest in many gardens throughout the country and is especially damaging to the roses, which it very often kills outright. Up to the present date it has not been noted on any other host and only a more extended search can determine whether it has extended its ravages to the native rosaceous flora. In this climate it has several broods per year and all stages can be found at almost any season. Adult

males are very numerous and their snowy puparia usually so cover the rose twigs as to make the latter appear as if white-washed.

This office has many notes on the collection of *A. rosæ*, among which are the following: on rose, Lima; on rose, Piura.

Ceroplastes sp. (near *ceriferus*)

Owing to the small number of specimens of this coccid and to a lack of literature describing the species of this genus, the writer cannot be *positive* of their specific determination, but the specimens in the government collection so closely agree with the description of *C. ceriferus* in "The Coccidæ of Ceylon" by E. E. Green, that they may be regarded as belonging to this species until proven something else. Moreover, *C. ceriferus* has been reported from Chili, Mexico, Antigua and Jamaica, in all of which exist climatic and other conditions very similar to those in the section of Peru where these specimens were found, so it is not surprising to find the aforesaid species present in this country as well.

Collected only at Huancabamba, on a thorny bush thought to be a species of *Mimosa*.

Chrysomphalus n. sp.? (near *rossi*)

Differs from available published descriptions of *C. rossi* in the presence of paraphyses, in having fewer circumgenital pores and in that the plates are broader, blunter and not so long and slender, and are less serrated.

On *Araucaria excelsa*, Lima; *Araucaria bidwilli*, Lima.

Coccus hesperidum Linn.

C. hesperidum is found attacking a large variety of hosts very generally throughout the Republic, but so thoroughly is it held in check by its numerous microhymenopterous parasites that it very seldom does appreciable damage and even in such isolated cases destruction by artificial means scarcely seems necessary.

Collected as follows: on a variety of *Dianthus chinensis*, Samán (Department of Piura); *Mangifera indica*, Coscomba (Department of Piura); *Cordyline terminalis*, Lima; *Datura arborescens*, Samán, (Department of Piura); *Ficus nitida*, Matucana; orange, Coscomba (Department of Piura).

Diaspis boisduvalii Sign.

It has often been noted by the writer that this coccid seems to have a decided preference for monocotyledonous plants and is especially troublesome on palms, often killing young plants. It is a very common scale in this country, being widely distributed and thriving out-of-doors in perfect vigor.

Recorded from this Republic on: *Cocos coronata*, Lima; *Areca nobilis*, Piura; *Areca nobilis* and *Pandanus utilis*, Lima.

Diaspis echinocacti Bouché

Found occasionally throughout the Republic on cactus, but, so far as known, attacking no other group of plants.

Recorded as follows: on *Opuntia* sp., Lima; on *Opuntia arborescens*, Acobamba.

Fiorinia fioriniæ Targ.

Of common occurrence upon various species of ornamental plants in the gardens and parks of various Peruvian towns but, so far, not collected on wild vegetation.

Noted as follows: on *Cocos* sp., Samán (Department of Piura); on *Phormium tenax*, Lima; on a cultivated, climbing *Asclepias*, Lima.

Hemichionaspis minor Mask.

This coccid is so closely related to *H. aspidistræ* as to be thought by some authorities to be inseparable from, or at least only a variety of, the latter. To the writer, however, it seems a valid species which can generally be separated from *H. aspidistræ* by various small differences; these taken separately, seem inconsequential, but in the aggregate cannot be denied recognition. The scale of *H. minor* is, as a rule, lighter in color than that of *H. aspidistræ*, is somewhat coarser in texture, thicker, not quite so slender and dainty looking and does not seem so smooth and shiny. The exuviæ of *H. minor* appear a trifle smaller in proportion to the size of the scale and contrast more in color with the latter, being of an amber to light-brown color or even of a dirty, dark-brown.

The median lobes of the adult insect seem to project a trifle more than in *H. aspidistræ* and lobes two and three do not seem quite so distinct as in the last mentioned species.

In Peru *H. minor* is known especially as a cotton plague and as such it is doing a great amount of damage in the northern cotton regions. The generally accepted opinion as to its introduction (as previously published by Prof. C. H. T. Townsend) is that it entered through the Port of Paita on some plants which were, doubtless, set out in the vicinity of Piura during the last eight or ten years, and from this focus it has gradually been spreading through the cotton fields of the Piura-Chira valleys until it has now become a very serious check upon not only the quantity but also the quality of cotton produced.

As cotton is by far the most important product of the region named, it is only natural that the "piojo blanco," as *H. minor* is there called, should be regarded primarily as a cotton pest, but its attacks are by no means confined to that plant and *Salix humboldtiana* as well as *Ricinus communis* are close seconds as hosts. This office possesses a great many notes relative to such attacks in many localities and at different dates and that the coccid in question is an omnivorous feeder

cannot be doubted after a glance at the following list of host plants, all but two of which are in addition to those recorded in Mrs. Fernald's "Coccidæ of the World." All localities mentioned are in the Department of Piura, Peru.

Collected quite generally on cotton; *Phaseolus* sp., *Ricinus communis*, *Salix humboldtiana*, watermelon, Coscomba; *Capsicum* sp., Sol Sol; *Ricinus communis*, Catacaos, and Macacará; *Prosopis juliflora*, Coscomba; *Asparagus officinalis*, Piura; *Sesbania* sp. Coscomba; *Yucca gloriosa*, Samán; Coscomba; Piura, "cereza," Coscomba; watermelon, Catacaos; *Malvastrum* sp., Hacienda San Jacinto.

Lepidosaphes beckii Newm.

Many years ago good oranges were grown in the vicinity of Lima but at present even a citrus *tree* is a rarity and all the citrus fruit is brought either from Ecuador, or small, well isolated valleys in different parts of the Peruvian Republic. This situation is caused by the ravages of various insect pests, among the most formidable of which is *L. beckii*, but today the scale is rarely encountered for the simple reason that its food plants have nearly all been destroyed wherever the scale has gained a foothold. Although many parasites are present they do not dominate their hosts to such an extent as to make the raising of citrus fruit. on a commercial scale, an attractive proposition in this section.

Lepidosaphes beckii has been collected by this office as follows: on orange trees, Lima, and at Hacienda Ñaña (between Lima and Chosica).

Two other species of *Lepidosaphes* have been collected in this Republic but as yet neither of them has been classified. The writer has repeatedly taken a small, light-colored species from citrus trees in the Department of Piura where it is a great hindrance to the growth of all species of *Citrus*, being especially common on the orange. It is also common on a plant which is parasitic on *Prosopis juliflora*.

The other species is very like *L. beckii*, but a close examination discloses differences, the best marked of which is its larger size and slightly different color. Taken by Professor Townsend on oranges from Pacasmayo.

Orthezia insignis Dougl.

Collected as follows: on *Justicia* sp., Lima; on *Ligustrum japonicum*, Lima; on *Duranta plumieri*, Lima; on *Jacaranda punctata*, Lima; on *Bignonia stans*, Lima.

Pseudaonidia articulatus Morg.

This coccid is the commonest, and most widely distributed of all those found in this country and is also the most omnivorous feeder, attacking as it does a very wide range of food plants. The hosts most generally infested are the different species of *Ficus* and *Citrus* trees, the latter being infested, almost without exception, throughout the Repub-

lic. In appearance *P. articulatus* is very like the red scale of California (*Chrysomphalus aurantii*) but here it does even more damage, in proportion to the number of citrus trees grown, than does the red scale in the citrus growing districts of the United States. But in considering this statement one must bear in mind that fumigation is never practiced in Peru and that parasites, even though exceptionally numerous, do not seem even to be a serious check on the multiplication of this insect, not to mention controlling it.

The following is a list of hosts and the localities where collected, to date, but additions are constantly being made as this inquiry into the coccid fauna of Peru progresses. Collected on: orange, Hacienda Mallares (Department of Piura); orange, Pueblo Tamarindo (near Paita); orange Chapairá (near Piura); orange, Hacienda Mallares (Department of Piura); orange, Coscomba (near Piura); lemon, Hacienda San Jacinto (near Paita); lime, Hacienda San Jacinto (near Paita); orange, San Bartolomé (Department of Lima); orange, Muñuela (Department of Piura); orange, Coscomba (near Piura); rose, Piura; *Anona muricata* and orange, Perené Colony (in the interior of Peru); *Anona cherimolia*, Chosica; *Ficus nitida*, Lima; *Ficus nitida*, Hacienda Ñaña (between Lima and Chosica); *Sambucus peruviana*, Piura, and Hacienda San Jacinto (near Paita); *Anacardium occidentalis*, Ñomala (in the Andean foothills, Department of Piura; *Jasminum arabica*, Lima; *Jasminum azoricum*, *Nerium oleander*, Lima; *Ligustrum japonicum*, Lima; *Plumieria* sp., Piura; *Cocos coronata*, *Washingtonia filifera*, *Erythria edulis*, *Kentia* sp., and *Cycas revoluta*, Lima; *Bignonia stans*, Piura; *Magnolia grandiflora*, Lima; *Eriobotrya japonica*, Chosica.

Pseudococcus citri Risso.

The above insect, in temperate climates, is generally considered as a greenhouse pest but in the warm, equable climate of Peru it is to be found out-of-doors in all localities where its food plants grow. It is very subject to both parasitic and predaceous enemies, however, and has not as yet been noted in any abundance in any one locality, although a slight search will reveal it almost anywhere in limited numbers. It is not a serious menace to any cultivated crop and, owing to this fact and its general distribution and comparatively slight numbers, only a few notes relating to it have been accumulated.

Collected on: *Coffea arabica*, Lima; *Gossypium peruvianum*, Hacienda San Jacinto (near Paita), and throughout the Department of Piura at different dates; *Asparagus officinalis*, Sol Sol (Department of Piura), (Rust) and Hacienda Mallares (near Paita); cotton, Lima.

Pulvinaria sp. nov. (?)

In the Department of Piura a species of Pulvinaria has repeatedly been collected but always in the immature stages so that it could not be classified. It is of medium size and green in color, and the beginning of an ova-sac, in a few cases, distinguished it from all coccus-like forms. Never seen in damaging numbers.

Collected on: *Gossypium peruvianum*, Hacienda Samán (near Paita), and at Paccha

(Department of Piura); *Batata edulis*, Sullana (Department of Piura); *Bidens* sp., Sullana.

Saissetia hemisphærica Targ.

This well-known coccid is of quite general occurrence in Peru, but as a rule the individuals are rather scattering, there often being only one or two on a single leaf or stem. Rarely, indeed, is it found in masses and even in such cases the individuals are soon killed off by parasites, so that a heavy infestation, with its consequent damage to the host, is very unusual.

Recorded as follows: on *Asparagus officinalis*, Piura; *Plumieria* sp., Piura; *Baccharis* sp., Perené Colony (interior of Peru); *Tessaria* sp., Perené Colony; *Bignonia stans*, Piura and Lima.

Saissetia oleæ Bern.

While the female of this species is common in many parts of Peru, the males have been seen here upon only a single occasion. On July 15, 1913, the writer collected hundreds of male propupæ on the undersides of the leaves of *Asclepias curassavica* at Chosica, from which many perfect males emerged within the next few days. Hitherto, California is the only locality from which the males have been reported (see Bulletin no. 223, Calif. Agricultural Experiment Station by H. J. Quayle and E. W. Rust), and it is of much interest to the writer again to be able to record them, especially at such a distance from where they were originally found.

S. oleæ has been noted as follows by this office; on cotton (*G. peruvianum*), Somate (Department of Piura), and at Catacaos; on cotton, Vitor (near Arequipa), and Coscomba (near Piura); on *Nerium oleander*, Lima; on *Asclepias curassavica*, Lima, and Chosica.

THE ECONOMIC STATUS OF THE FUNGOUS DISEASES OF INSECTS

By R. W. Glaser, *Bureau of Entomology*

There can be no doubt that at certain times of the year, under certain conditions, epidemics of fungous diseases naturally contribute much toward controlling noxious insects. This, however, is a balance established by nature of her own accord. Can we help her?

Let us suppose that a given locality is heavily infested by a noxious insect; also that a number of individuals in this locality have died from fungus parasitism and, lastly, that we have found an infested locality free from such a fungus. We will naturally ask ourselves the following questions:

(1) Can we cultivate this fungus?

(2) Can we introduce it into the infested locality where it is not known to occur?

(3) Will the fungus establish itself and will it spread and become effective?

On the whole, a favorable answer can be given to the first two questions. Many of the parasitic fungi have been cultivated on artificial media or on living insects kept in confinement. Such fungi have been introduced among healthy insects when the occasion warranted such procedure. The third question, however, has offered difficulties which in most cases have been insurmountable. Fungi are very dependent upon external conditions and in many cases the apparent absence of a particular fungus in a locality is usually an index of conditions unfavorable for its development, and an artificial introduction will be useless. If a fungus does establish itself in a locality it may not spread far from the centers of artificial infection, showing that conditions are favorable in and near the centers of infection, but not beyond them. A certain amount of success has been achieved in one case and I will give an account of this after having presented some of the difficulties which were encountered by competent investigators who showed that in general the economic value of certain fungi has been overestimated.

In 1892, Franz Tangl, at one time interested in this subject, and now a well known physiologist at the University of Budapest, performed some infection experiments on nun moth caterpillars by using spore emulsions of *Botrytis bassiana*. In the laboratory the experiments succeeded, since all of the infected caterpillars died of "muscardine." Infection experiments in nature, however, where infested trees were thoroughly sprayed with spore emulsions, gave negative results. The nun moth caterpillars flourished as before. V. Tubeuf, who has done a great deal of work on caterpillar diseases, tried a series of similar experiments, and likewise obtained negative results when he tried to infect caterpillars in nature with *Cordyceps militaris*.

Recently Billings and Glenn (1911) in attempting the artificial use of *Sporotrichum globuliferum*, the etiological factor of the white fungus disease of chinch bugs in Kansas, have reached very similar conclusions. In a summary of their experiments, they say:

(1) "In fields where the natural presence of the fungus is plainly evident, its effect on the bugs cannot be accelerated to any appreciable degree by the artificial introduction of spores.

(2) "In fields where the fungus is not in evidence spores introduced artificially have no measurable effect.

(3) "Apparent absence of the fungus among chinch bugs in a field is evidence of unfavorable conditions rather than lack of fungous spores.

(4) "Laboratory experiments can be made to prove that artificial infection accomplishes results upon bugs confined in cramped quarters and without food, but in the field, where fresh and usually drier air prevails and food is abundant, an entirely different situation is presented."

In 1912, Morrill and Back performed a large series of experiments in Florida to determine whether or not fungi could be used artificially in suppressing the white fly in the citrus groves. It has been known that fungous diseases are very important factors in the natural control of this insect. The most important species of fungi in this respect are *Ægerita webberi* Fawcett, the brown fungus, *Aschersonia aleyrodis* Webber, the red fungus, and *Aschersonia flavocitrina*, the yellow fungus.

In attempting to use the above fungi artificially Morrill and Back concluded that:

(1) "The fungus parasites thrive only under suitable weather conditions during a period of about three months each year; generally speaking the summer months in the case of the two Aschersonias and the fall months in the case of the brown fungus.

(2) "Under natural conditions, without artificial assistance in spreading, the fungi have ordinarily, in favored localities, controlled the white fly to the extent of about one-third of a complete remedy through a series of years.

(3) "The infections secured by artificial means of introducing fungi, while successful in introducing the fungi, have thus far proved of little or no avail in increasing their efficacy after they have once become generally established in a grove.

(4) "Experiments by the authors, and by citrus growers in coöperation with the authors, involving the treatment of thousands of trees with suitable "checks" or "controls" have shown that when fungus (red or yellow *Aschersonia*) even in small quantities is present in a grove, there is no certainty that from three to six applications of fungus spores in water solution will result in an increased abundance of the infection on the treated blocks of trees by the end of the season. In some of the most important and carefully planned and executed experiments, the fungus has increased more rapidly in sections of the groves which were not sprayed with spore solutions than in the experimental blocks."

We must now consider *Entomophthora aulicæ*, the brown-tail fungus, which is the only case familiar to me where an artificial use of a fungus has proved successful to a certain extent. Speare and Colley, the authors of a paper on this subject in 1912, say that it can not be re-

garded as a "cure all" for the brown-tail moth, but is very important as a powerful check.

They give the following directions for the use of the fungus: "The Entomophthora under consideration may be used effectively in the spring and early summer, when the larvæ have left their nests and in the autumn for several weeks before the webs of the new broods are closed for the winter. During both of these periods the rapid spread of the disease is largely dependent on weather conditions, and when these conditions—warm nights and damp atmosphere—favor the growth of the fungus, artificial distribution yields truly satisfactory results, and may bring about enormous and widespread destruction." . . . "In the spring, when the caterpillars are scattered all over the trees, it is comparatively easy to place the infected larvæ in among them, but in the autumn, when they are localized, feeding in the immediate vicinity of the nest, it is necessary to infect individual nests. Experience seems to point to the autumn, however, as the more advantageous time to start the artificial epidemic."

A detailed account of the methods used for the propagation and dispersion of the brown-tail fungus will be found in the paper of these authors. Suffice it to say that the fungus has accomplished much good and when the proper conditions for its introduction are selected, a destruction of from 63 to 100 per cent. of the caterpillars in the planted areas can be depended upon. An intelligent use of the brown-tail fungus should be encouraged, for the results obtained in Massachusetts during the last two or three years justify a serious consideration of the matter. Professor Roland Thaxter, the well-known cryptogamic botanist, told me that he could not think of any way in which the State Forester of Massachusetts could spend a few thousand dollars a year to better advantage than in the propagation and dispersion of the brown-tail fungus.

ON THE CAPTURE OF LIVING INSECTS BY THE CORN-FIELD ANT (LASIUS NIGER AMERICANUS)

By Wesley P. Flint

During some experimental work on the corn-root aphis done at Bloomington, Ill., in the summer of 1909, the movements of *Lasius americanus* were closely observed every night for nearly two months by Mr. G. E. Sanders and myself. It was frequently noticed that on warm nights, when these ants were very active, they would attack and kill many small insects that came near their nests. This was first seen on a very warm night in August, when a large nest of ants

of this species was being watched by the aid of a red carbide lamp. A back-swimmer (Notonectid) happening to alight among several *Lasius* workers, one of the ants at once seized the back-swimmer by one of its legs. In a few seconds twenty or more ants were crowded about the insect, many holding to it, and in less than two minutes it had been dragged into the *Lasius* nest. During the next few minutes the ants killed a number of small Jassids that, attracted by the lamp, alighted among them. Often an ant would capture a Jassid as large as itself and carry it into the nest.

On this and other warm nights when the ants were very active, a number of living insects were placed near their nests, and in nearly all cases these were quickly caught and killed. If at first only a few ants were on the ground near the nest entrance and a small insect such as *Diabrotica longicornis* was dropped among them, as soon as the ants on the surface began to struggle with the beetle, others would come out of the nest in such numbers that several hundred would sometimes be gathered about the entrance. When a large number were assembled in this way, they would attack and kill insects of considerable size. *Diabrotica 12-punctata*, *D. longicornis*, and *Agonoderus pallipes* were readily killed. The ants seem to be especially fond of the last-named beetle for food, as they may often be seen dragging it to their nests. *Heliothis obsoleta* larvæ, nearly full grown, were killed after a short struggle; and even adult Epicautas, both *E. marginata* and *E. vittata*, were killed after a hard struggle, as were also many small beetles and moths. *Lasius* does not, however, seem able to kill Pentatomids of any size. Insects of this family were frequently dropped among the ants, but always escaped if not first injured. Even when killed they were seldom dragged within the nest, and it would seem that the odor of these insects is offensive to the ants.

One point of considerable interest was the manner in which the ants caught the insects. In very many cases they would seize their prey by the legs and hold them in this way until killed by the bites of other ants on the head or abdomen; but more frequently an ant would get on the back of its victim and hold it by the antennæ until killed by other workers. In some cases an insect would take flight and carry the ants, hanging to its legs, for some distance. The effect of the ant bites must have been very poisonous to most of the insects killed, as *Diabrotica longicornis* was often killed in thirty seconds, *Agonoderus pallipes* in a minute or less, and other larger insects in a surprisingly short time. It was very evident that when very active *Lasius americanus* will attack any insect that happens near its nest; and, while many escape, the total number killed by these ants in the course of a season must be very large.

Lasius was often found in large numbers in the piles of cow and horse manure dropped by cattle and horses in pastures. It was noticed that, when this manure was disturbed, the ants promptly carried away any dipterous larvæ that might be exposed. Examination of a large number of these piles of droppings showed that the number of dipterous larvæ found in the droppings where *Lasius americanus* was present was much less than in those in which no ants were found. Several nearly fresh piles of droppings, containing large numbers of maggots but no ants, were taken from the pastures and placed in a corn field over a large nest of *Lasius americanus*. When examined three days later only one puparium and one larva with ants feeding upon it was found. There had been at least seventy-five maggots in the manure when it was placed over the ants' nest.

Office of the Illinois State Entomologist.

THE CALIFORNIA PEAR THRIPS IN MARYLAND

By W. M. Scott,

Research Department, Thomsen Chemical Co., Baltimore, Md.

On April 25, 1913, the writer observed a blighted condition of the blossoms and leaves in a small Kieffer pear orchard near Baltimore, Md., and a closer examination disclosed the fact that the trees were literally alive with thrips. The leaves were curled and blackened at the tips and around the margins, and most of the blossom clusters had been destroyed.

The common pear thrips of California, *Euthrips pyri* Daniel, was suspected, but only larvæ were present, the adults having disappeared, and the species could not therefore be identified.

Keeping this interesting outbreak in mind, the writer visited the same orchard again on April 22, 1914, when the blossoms were beginning to open, and found adult thrips present in great numbers. Specimens were sent to Prof. A. L. Quaintance, of the Bureau of Entomology at Washington, who reported that Mr. J. D. Hood, of the Biological Survey, had examined them and identified the species as *Tæniothrips* (*Euthrips*) *pyri* Daniel.

This establishes a new locality for the pear thrips which has the reputation of being the most destructive fruit tree insect in California. Foster and Jones[1] place "the damage caused by the pear thrips, in the Santa Clara Valley alone, during the years from 1904 to 1910 at nearly $2,000,000." The question of interest to both entomologists and

[1] U. S. Dept. of Agr., Bur. Ent. Cir. No. 13, p. 2.

fruit growers is, will it prove to be as destructive in the East as it has been on the Pacific Coast? The results of its work in the Maryland orchard indicate that it is capable of completely destroying a crop of Kieffer pears. On May 5, 1914, the writer examined this orchard again and found that, although the trees had bloomed profusely, no fruit had set, the blossom clusters having dried up. There was no crop in 1913, but this might have been due to a spring frost which the owner at the time thought killed the blossoms. In 1914, however, there was no frost during the blooming period and no pear blight could be found in the orchard, so that the thrips was apparently the sole cause of the loss this year.

For many years this insect, so far as known, was confined to a few counties of California, but in 1912 Parrott[1] reported it as occurring at several points in the Hudson River Valley of New York and the Maryland occurrence establishes it in a third state. Its discovery in other localities will probably follow in rather rapid succession until it becomes one of our common orchard pests.

So far as the writer knows, the Maryland outbreak is at present confined to the orchard of Mr. Roland Phelps at Brooklyn, about four miles from Baltimore. This orchard consists of about two hundred Kieffer pears with perhaps half a dozen Le Conte and Seckel pears mixed in. These latter varieties were affected almost, if not quite, as much as the Kieffer. The thrips also occurred on some nearby peach and apple trees, but caused very little damage to these. Other pear orchards in the same neighborhood were examined, but no thrips found.

DESCRIPTION OF A NEW SAWFLY INJURIOUS TO STRAWBERRIES[2]

By S. A. Rohwer

The following species is described at the request of Professor R. L. Webster who has been working on the life-history of this species for a number of years and who has prepared a paper dealing with the biology and economics of the species of *Empria* injurious to strawberries in Iowa.

The species of *Empria* are closely related and the group is in bad need of revision. As far as the author's experience with the genus

[1] N. Y. Agr. Expt. Sta. Bul. No. 343, p. 13.

[2] Contribution from the Branch of Forest Insects, Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C.

has gone he is of the opinion that the most reliable specific characters are to be found in the sheath, saw, antennæ, certain parts of the head and color. Certain characters of the head such as the exact extent and definition of the median fovea and antennal furrows and the exact dentations of the clypeus are, it would seem, subject to variation and cannot be used as rigidly as in other groups.

Empria fragariæ, new species

Judging from the literature this species is related to *castigata* MacGillivray. Specimens were sent to Dr. A. D. MacGillivray who compared them with his type and stated that they differ from that species in the "form of the saw guide which has the distal end truncate with rounded corners, while in the specimen sent the lower corner is rounded off. The median fovea is only a rounded scar in *castigata* and a deep rounded pit in the specimen sent." This species has no doubt been identified as *ignota* Norton, and probably some of the writings dealing with the biology and economics of *ignota* refer more properly to *fragariæ*.

Female: Length 6.5 mm.; length of antennæ 2 mm. Clypeus more coarsely sculptured toward the apex, the apical margin tridentate, the lateral lobes broadly, obtusely triangular with the median tooth small and obtuse; supraclypeal area convex, slightly more strongly convex ventrally, but in outline nearly rectangular; antennal and supraclypeal foveæ confluent, but the former are not as deep as the punctiform supraclypeal foveæ; antennal furrows complete but not as deep opposite crest; middle fovea elongate, and more or less connected with the elongate depression from the anterior ocellus; postocellar area well defined; postocellar furrow nearly straight; a deep furrow from the anterior ocellus to the postocellar furrow; postocellar line distinctly shorter than the ocellocular line; face and front to the level of the anterior ocellus distinctly sculptured; vertex and posterior orbits shining, with setigerous punctures; antennæ short, stout, the third antennal joint distinctly longer than the fourth, the fourth and fifth subequal; mesonotum shining, impunctate; stigma broader at base where it is subangulate, gradually tapering to the radius from which it is obliquely truncate to the costa; third cubital cell slightly longer than the second, twice as wide anteriorly as basally; hind wings with one discal cell; sheath straight above, obtusely rounded at the apex and gently rounded on the lower margin. Black; two elongate spots on the posterior margin of the pronotum, tegulæ almost entirely, lateral spots on the second, third and fifth tergites, white; legs black; apices of the four anterior femora, four anterior tibiæ beneath, extreme base of the posterior tibiæ, white; wings dusky hyaline, venation dark brown.

Male: Length 5 mm. Agrees fairly well with the above description of the female. The hypopygidium is broadly rounded.

According to the specimens examined this species varies in the dentation of the clypeus, inasmuch as the median tooth is decidedly reduced in some specimens and slightly accentuated in others (in these latter the supraclypeal area and clypeus become subcarinate); and in the extent of the middle fovea, as the impressed line from the anterior ocellus varies in depth and definition. The most reliable criterion for determining this species is the shape of the sheath, general color, well-defined postocellar area and short antennæ.

Ames, Iowa. Described from one female (type) labelled "Experiment 113 (1911), April 7, 1912," and one male (allotype) labelled in the same fashion. The paratypes bear various "Experiment" numbers and most of them are reared. Certain specimens of this species were also collected around Storm Lake, Iowa, on May 2, 1912 by R. L. Webster.

Type, allotypes and paratypes in the U. S. National Museum under Catalog Number 18357. Other paratypes in the collection of Dr. A. D. MacGillivray and in the collection of the Experiment Station at Ames, Iowa.

ARTHROCNODAX CONSTRICTA n. sp.

By E. P. Felt, *Albany, N. Y.*

The midges described below were reared from garden beans infested with the common red spider, *Tetranychus bimaculatus*, and probably predaceous thereupon. The specimens were collected by Thomas H. Jones, June 21, 1913, at Rio Piedras, P. R. The species runs in our key to *A. rhoina* Felt, from which it may be easily separated by the greater length of the distal part of the stem of the fifth antennal segment and the marked differences in genitalia.

Male: Length 1 mm. Antennae fully as long as the body, sparsely haired, yellowish-brown, yellowish basally; 14 segments, the fifth having the basal portion of the stem with a length one-fourth greater than its diameter, the distal part with a length two and one-half times its diameter. Palpi: the first segment subquadrate, the second narrowly oval, the third and fourth nearly equal, each with a length nearly four times the diameter. Mesonotum yellowish brown, the submedian lines yellowish. Scutellum yellowish brown, lighter apically, postscutellum yellowish. Abdomen yellowish brown. Halteres pale yellowish. Coxae and legs mostly yellowish straw, the pulvilli nearly as long as the claws. Genitalia: basal clasp segment long, slender; terminal clasp segment rather long; dorsal plate short, broadly and roundly emarginate; ventral plate long, broad, roundly truncate; style long, rather slender and strongly constricted near the distal third.

Female: Length 1.25 mm. Antennae nearly as long as the body, sparsely haired, yellowish, the fifth segment with a stem one-fourth the length of the cylindric basal enlargement, which latter has a length about two and one-half times its diameter, the fourth palpal segment distinctly longer than the third. Ovipositor pale yellowish, the terminal lobes narrowly oval, tapering distally and thickly haired. Other characters nearly as in the male. Type C. a2572.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

DECEMBER, 1914

The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published, so far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceding publication. Contributors are requested to supply electrotypes for the larger illustrations so far as possible. The receipt of all papers will be acknowledged.—EDS.

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The Philadelphia meeting promises much to prospective attendants. Its convenient location in respect to the more active entomological centers indicates a record-breaking gathering with a corresponding enthusiasm. Discussion and criticism based upon numerous viewpoints means the elimination of the unsound and the confirmation of results based upon correct fundamentals. The historical associations and the opportunities to consult the older collections of American insects, some very rich in types, present attractions not duplicated by many localities.

The continuance and spread of the fierce struggle in Europe means that little along scientific lines may be expected from the devastated areas for some time, possibly for years, and lays upon Americans an increasing responsibility for work along productive lines. The opportunities for investigation of the relation of insects to disease are particularly good and, as pointed out in a recent presidential address, relatively few have given attention to this phase of our science. This is especially true in America. Corps of practical entomologists devote their entire time to a study of insects injuring certain crops and, as yet, almost nothing of the kind has been attempted in this country. The exhaustive studies of purely agricultural insects have yielded practical results of great value and the same may be expected to follow a similar concentration along other lines.

Reviews

Die wichtigsten Krankheiten und Schädlinge der Tropischen Kulturpflanzen, by Dr. Friedrich Zacher, Band I. 152 pages, 58 text figures. Hamburg. Verlag Fr. W. Thaden. 1914. (Deutsche ropen-Bibliothek Bd. 10.)

This little volume treats of the insect and other animal pests as well as the bacterial and fungous diseases which attack tropical plants. The author explains the manner in which diseases are spread by animals, and how they often follow the attacks of insects.

The greater portion of the book, pages 39 to 152, is devoted to a discussion of the pests of cotton, cocoa, coffee and tea. Each important pest is treated separately and remedial treatment is recommended. Most of the illustrations are made in half-tone from drawings or photographs and are of fair quality. The book is supplied with a table of contents, but there is no index.

W. E. B.

Insects Injurious to the Household and Annoying to Man, by Glenn W. Herrick, pages i–xviii, 1–470, figs. 152. Macmillan Company. 1914.

We have in this small volume a concise and authoritative discussion of a large number of insects more or less directly injurious to man or his household possessions. The work is an indirect outcome of the studies of recent years upon insects as disease carriers, though the author does not attempt to exhaust this phase of the problem.

The first 34 pages are devoted to the house-fly while associated and much less important flies occupy the second chapter of 19 pages. The various mosquitoes, their habits and control are allotted about 50 pages. Short chapters are devoted to the bed-bug, cockroaches and fleas respectively. There is an excellent discussion of the various household ants, which, taken with the matter relating to the Termites (unlike though popularly associated forms) leaves little to be desired. The fabric, cereal and other food pests receive due attention and in concluding chapters there are discussions of human parasites, annoying pests, dry wood borers, poisonous or terrifying insects, presenting much of interest concerning common though not well-known forms. There is an excellent series of illustrations, mostly original, the printing is good and the arrangement tasty.

The general public will find in this volume much practical information presented in a pleasing, untechnical manner, while for the entomologist it means another exceedingly useful compilation illuminated by personal experiences in both North and South and supplemented by excellent bibliographies.

E. P. F.

Current Notes

Conducted by the Associate Editor

Mr. W. S. Regan has been appointed assistant in entomology at the Massachusetts Agricultural College.

Dr. J. R. Dickson, health officer of Trinidad, W. I., visited the Bureau of Entomology on September 18.

Mr. C. E. Wilson has succeeded Mr. R. E. Lobdell as assistant zoölogist and entomologist at the Mississippi station.

Dr. M. T. Smulyan has recently been appointed assistant to the state entomologist of Virginia, with headquarters at Blacksburg.

Mr. C. C. Hill, 1914, Massachusetts Agricultural College, is now connected with the Bureau of Entomology, and is located at Nashville, Tenn.

Mr. C. M. Packard, Bureau of Entomology, Hagerstown, Md., has been transferred to Hessian fly investigations at Wellington, Kan. Mr. Packard was married July 29.

Mr. W. V. King, Bureau of Entomology, has returned to New Orleans, La., where he will resume his work in the medical department of Tulane University.

Mr. H. C. Eagerton of the South Carolina Experiment Station has been appointed assistant entomologist in the Estacion Agronomica at Santiago de las Vegas, Cuba.

Mr. Ralph R. Parker, who has been studying the fly problem in Montana during the summer, has returned to continue his graduate work at the Massachusetts Agricultural College.

Mr. W. D. Pierce, Bureau of Entomology, has spent the month of September in determining the spread of the cotton boll weevil in Florida, Alabama and Mississippi.

Mr. H. P. Wood, Bureau of Entomology, has been granted leave of absence without pay for the purpose of taking a course in tropical medicine at Harvard University.

Mr. Stanley B. Freeborn, class of 1914, Massachusetts Agricultural College, is assistant and engaged in teaching economic entomology and veterinary parasitology, at the University of California.

Mr. James M. Langston, Bureau of Entomology, has been transferred from Nashville, Tenn., to Greenwood, Miss., where he will assist Mr. C. F. Turner in charge of the laboratory at that point.

Mr. A. W. Jobline Pomeroy has received the appointment as entomologist for the Department of Agriculture for southern Nigeria. He will proceed to his post from Liverpool on November 25.

Mr. J. D. Luckett, Bureau of Entomology, assigned to work under the Insecticide and Fungicide Board, at Vienna, Va., resigned September 5, in order to resume school work at Purdue University.

Mr. J. F. Strauss, Bureau of Entomology, has recently returned from a trip to Germany. While in Germany he collected a number of aphids on fruit and garden crops, which are of considerable interest.

At the invitation of the Florida Agricultural Experiment Station, Mr. W. W. Yothers, Bureau of Entomology, gave an address before the Citrus Seminar, held at the University of Florida, Gainesville, Fla., on September 22.

Mr. E. W. Laake, Bureau of Entomology, in company with Doctor Johnson, of the Bureau of Animal Industry, is investigating a serious outbreak of anthrax in western Texas, in which transmission by horse flies seems to be indicated.

Dr. William Saunders, author of "Insects Injurious to Fruits," since 1886 director of the Central Experimental Farms of the Dominion of Canada at Ottawa, and a member of this Association, died September 13, in his seventy-ninth year.

Mr. J. R. Horton, Bureau of Entomology, who is in charge of the Subtropical Field Station at New Orleans, La., was recently called to St. Louis, Mo., owing to the death of his brother as the result of an accident.

Mr. R. S. Vaile, collaborator, Bureau of Entomology, and until recently horticultural commissioner of Ventura County, Cal., will continue as collaborator with headquarters at Berkeley, where he has been appointed assistant professor of orchard management in the University of California.

Mr. W. E. Pennington, Bureau of Entomology, has been transferred from Wellington, Kan., to the Hagerstown (Md.) Laboratory to take the place vacated by C. M. Packard, who is now at Wellington, Kan., assisting Mr. E. G. Kelley in the Hessian fly investigations.

Mr. A. C. Cameron, a research student of the British Board of Agriculture, who has done notable work on the entomology of the soil of England, and who has spent several months in New Jersey, visited Washington on September 23.

Mr. M. M. High, entomological assistant, Bureau of Entomology, engaged in investigations of onion insects and the insect enemies of other vegetable crops at Knox, Ind., leaves these headquarters for Brownsville, Tex., where he will work on the same problems.

Mr. P. R. Myers, who for several years was connected with the division of insects in the United States National Museum, has received an appointment in the Bureau of Entomology, and has been detailed to assist Mr. W. R. McConnell at the Hagerstown (Md.) station.

Mr. William B. Parker, Bureau of Entomology, who has been engaged during the year in investigation of insects injurious to stored products and other projects at Sacramento, Cal., has accepted the position of farm adviser under the auspices of the University of California, with headquarters at Ventura, Cal.

Messrs. T. E. Holloway and G. N. Wolcott, Bureau of Entomology, returned from Europe about the middle of September. Mr. Holloway spent the entire month of August in Paris. He has returned to his station at New Orleans and Mr. Wolcott has resumed his work on *Lachnosterna* parasites at Urbana, Ill.

Mr. John N. Summers, Bureau of Entomology, who has been traveling in Europe for several months studying gypsy moth and brown-tail moth conditions, reached New York on September 12. Mr. Summers' return to Melrose Highlands, Mass., was somewhat delayed on account of the chaotic condition existing in Europe caused by the war.

Prof. A. L. Quaintance, Bureau of Entomology, left Washington about the middle of September for a trip through the Western States to confer with the men who are in charge of various deciduous fruit insect field stations. En route he will visit the following stations: North East, Pa.; Benton Harbor, Mich.; Grand Junction, Col.; Walnut Creek, Cal., and Wenatchee, Wash.

Mr. R. J. Fiske was appointed August 20 to the position of scientific assistant in the Bureau of Entomology, and has been stationed temporarily at Grand Junction, Col., where he will carry on investigations of the codling moth. Mr. Fiske is a graduate of the Massachusetts Agricultural College, class of 1910, and before entering the Bureau was engaged in entomological work in Porto Rico.

Mr. N. E. Shaw, chief inspector, Department of Agriculture, Columbus, Ohio, reports that several gypsy moth egg-clusters have been found on a shipment of stone received in Ohio from Massachusetts. This occurrence emphasizes the necessity of action being taken to prevent the distribution of egg-clusters into uninfested territory on shipments not subject to inspection by the Federal Horticultural Board.

Mr. Leonard S. McLaine, assistant to Dr. C. Gordon Hewitt, dominion entomologist of Canada, has recently returned to Canada. Mr. McLaine has been stationed at the Gypsy Moth Laboratory, Melrose Highlands, Mass., and has been engaged in collecting parasites of the gypsy moth and the brown-tail moth for shipment to New Brunswick and Nova Scotia, where an attempt will be made to colonize these species.

Mr. R. S. Woglum, Bureau of Entomology, who is in charge of the investigation of citrus insects in California, reports that the mealy bug investigations are progressing in a satisfactory manner. The life history of *Pseudococcus citri* for this season of the year has been determined, and preliminary life history work has been undertaken with a Chrysopid and Hemerobiid, predatory enemies of the citrus mealy bug.

There is an unusual outbreak of *Alabama argillacea* in the Southern States this season, and moths have appeared at lights in northern localities. Notes are desired from as many northern localities as possible regarding the exact dates of the first appearances of these moths, the dates of the maximum appearances and of the disappearance of the insect. Records of this kind have been kept for several years, and notes made during the present season will be especially valuable.

In connection with the work on the wilt disease of the gypsy moth, which is being carried on by Messrs. R. W. Glaser and J. W. Chapman, at the Bussey Institution, a number of quite similar polyhedral diseases have been found in native caterpillars. In case caterpillars are found which have apparently died from any bacterial disease in any part of the country, or at any of the field stations of the Bureau, a small number of specimens are very much desired for study. These can be shipped in a dry condition, but it will facilitate the work very much if a note accompanies the sending stating where the caterpillars were found and giving any other information about the species concerned.

The thirty-fourth annual Museum Expedition of the Department of Entomology, under the direction of the Curator of the Museum, Professor S. J. Hunter, spent the month of August in the Rocky Mountains, in Southwestern Colorado, working along the New Mexico line. There were six (S. J. Hunter, H. B. Hungerford, Raymond Beamer, Wm. Brown, fellow, F. Poose, research, the cook) in the party and they returned with eight thousand specimens.

A new edition of the Naturalists' Directory has just been published by S. E. Cassino, Salem, Mass. This directory is invaluable to naturalists since it is the means of bringing together students and collectors in all parts of the world through correspondence. The directory contains an alphabetical list of English-speaking professional and amateur naturalists in all parts of the world, also a list of scientific societies and periodicals. The price of the Directory is $2.50 in cloth binding and $2.00 in paper binding. Sent postpaid. As only a limited edition has been printed, it is advisable for any one wishing a copy to order at once.

CARNEGIE SCHOLARS IN ENTOMOLOGY VISIT THE UNITED STATES

Mr. C. W. Mason has returned to England and will accept a post in one of the African colonies.

Mr. M. E. MacGregor has returned to England and will take a lectureship at Oxford in medical zoölogy.

Mr. H. A. Ritchie is still in this country and is now making a trip through the Southern States.

Mr. G. H. Corbett and Mr. E. Hargreaves reached Washington late in August and are at present visiting the stations at Clarksville, Tenn., Batesburg, S. C., and Orlando, Fla.

Mr. E. R. Speyer, of Cambridge, is at present in Washington and will study forest insects, starting in October for a visit to the far western forest insect stations. He will return to England in December and proceed to Ceylon for the purpose of studying the tea Scolytid.

Still another Carnegie scholar, Mr. H. G. Champion, is expected to arrive in October to study forest insects. He is a son of the well-known entomologist, Mr. C. G. Champion.

SUSCEPTIBILITY OF *Pollenia rudis* TO NICOTINE.—The "cluster fly" has been very numerous and quite annoying to the members of the staff in different laboratories of this Station during the past fall. It occurred to the writer to try a nicotine preparation (nicotine 90 per cent, water 10 per cent), which was applied by means of a small wad of cotton to the sills at the base of the window panes, the liquid being used in sufficient quantities to slightly moisten the wood. The effect on the flies was most marked, causing the death of a large percentage of the insects within a short period of time. This treatment has been frequently tested with similar results, and because of these experiences other laboratories in the institution have been influenced to use this method of destroying the pests. Black Leaf 40 proved to be equally effective as the foregoing preparation, although it is somewhat less rapid in its effects upon the creatures. With dark wood there was very little evidence of discoloration, but with windows coated with a light paint it would be desirable to place a narrow strip of cardboard on the sill before applying a nicotine preparation.

P. J. PARROTT.

Mailed November 30, 1914.

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